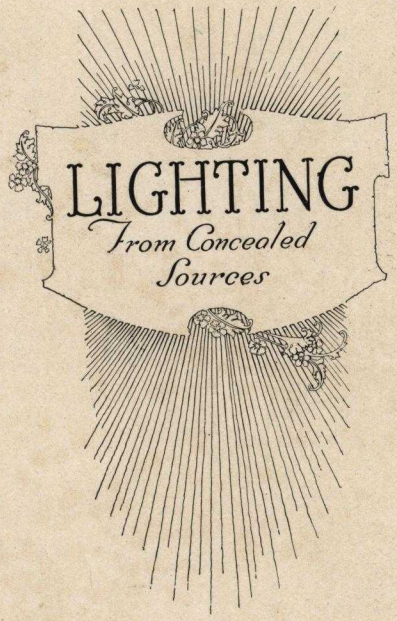
LIGHTING
from Concealed Sources

A. C. CALDWELL
DEC 8 1920


LIGHTING
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Sources

LIGHTING
from Concealed Sources

a
Practical Treatment
of
Lighting Problems
to obtain
Satisfying Illumination
& Individual Effects
without
Exposed Light Sources

by
The Engineering Department
J.L. STAIR *Chief Engineer*
of the
NATIONAL X-RAY REFLECTOR COMPANY
New York Chicago

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NATIONAL X-RAY REFLECTOR COMPANY

FOREWORD

THE effect of a correct principle steadfastly adhered to in any enterprise will bring about immeasurable results.

We have found this to be true in adapting as fundamental the fact that lighting should be from sources concealed.

The material to be found on the following pages is an elaboration of the principle which is expressed in the very title of the book—showing how its applications can be extended into practically every field where artificial lighting is required.

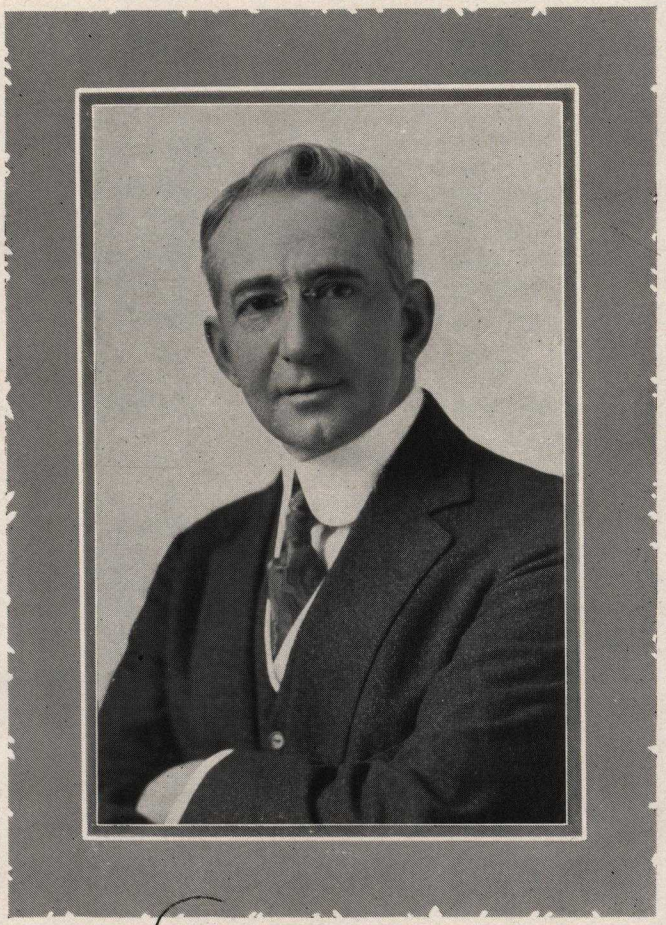
Examples presented are intended to indicate methods which are characteristic and only facts which have stood the test of time and experience are to be found herein.

It is quite impossible to include all variations or to show in a book of this kind a full scope of the activities of the National X-Ray Reflector Company in the field of Illumination.

Although intended primarily for the convenience of the Architect, Lighting man and Contractor, these pages contain many ideas that will be found valuable to light users. Owners, superintendents of buildings or those contemplating the construction of buildings of any kind will find useful data in this book.

If this volume serves to promote an interest in rational lighting, in illumination that combines the artistic and the utilitarian, without glare or eye strain, its purpose will have been fulfilled.

WE wish to express our sincere appreciation to those builders—Architects, Engineers, and Contractors—whose faith in X-Ray Lighting has assisted us in developing and applying correct methods of illumination from concealed sources by carrying this principle into the business of building.



Augustus D. Curtis

whose vision, enthusiasm, and realization from the start of the correctness of the principle of lighting from concealed sources has resulted in making its practical applications available to all. :: :: ::

CONTENTS

(For Alphabetical Index of Subjects See Page 241)

Page

FOREWORD 5

HISTORY OF X-RAY LIGHTING 11

THE X-RAY REFLECTOR. 13

I ILLUMINATION FROM CONCEALED SOURCES 17
The correctness of the principle.

II THE CONTROL OF LIGHT 19
Laws of light reflection—Their influence on lighting equipment design.

III INDIRECT LIGHTING 21
The general principles—The luminous bowl principle—Artistic fixtures—The Ferree test for eye efficiency.

IV PLANNING INDIRECT LIGHTING. 29
Equipment for indirect lighting—Methods of figuring—Charts for quick calculations.

V APPLICATIONS OF INDIRECT LIGHTING 39
Offices — Banks — Stores — Shops — Display Rooms — Clubs — Hotels — Schools — Libraries — Factories — Drafting Rooms — Churches — Auditoriums — Theatres — Restaurants and Dining Rooms—Hospitals—Hospital Operating Rooms—Residences —Public Buildings.
Detail Plates 80

VI LIGHTING FROM OTHER THAN CEILING OUTLETS 89
Coves and Cornices—Bank partitions—Floor Pedestals—Wall Boxes—Column Clusters —Brackets, etc.

VII THE CURTIS PORTABLE LAMP. 101
The mechanism—The Curtis Portable in the home—Other uses—The Adapter.
Detail Plates 106

VIII DIRECT LIGHTING 115
Its general uses—Reflectors for direct lighting.

IX PLANNING DIRECT LIGHTING. 121
Methods of figuring—Charts for quick calculations—How to install reflectors.

X APPLICATIONS OF DIRECT LIGHTING 129
Industrial, Shops, Factories, and Work Rooms—Foundries—High interiors—Erecting Shops — Mills — Power Plants — Printing Plants — Armories — Gymnasiums — Garages — Pool Tables — Bowling Alleys—Swimming Pools — Letter Cases — Public Markets—Skylight lighting—Stage lighting—Tennis Courts—Quotation Boards.
Detail Plates 152

XI SHOW-WINDOW LIGHTING 161
General principles—Show-window lighting equipment—How to select Reflectors.

Page

XII PLANNING SHOW-WINDOW LIGHTING 169
A typical show window—The Arcade window—Double deck windows—Show windows with glass ceilings—Indirect lighting in show windows—Diffused lighting for show windows—The show-window valance.
Detail Plates. 178

XIII SHOW CASE AND WALL CASE LIGHTING 181
The "Scoopette" and its applications—The "Hoodette" and its applications.

SPECIAL USES FOR SCOOPETTES AND HOODETTES 188
Deskette—Bankette—Music Rack units—Picture Lighting, etc.

XIV FLOOD LIGHTING 193
Uses and units for flood lighting—The X-Ray Projectors—Illumination Data—How to figure Flood Lighting.

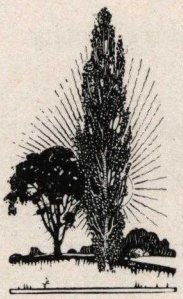
XV APPLICATIONS OF FLOOD LIGHTING 207
Buildings—Monuments—Signs—Flood Lighting for protection—Bridges—Amusements—Flag Lighting—Special uses—How to mount projectors.
Detail Plates. 222

XVI BANK DESK LIGHTING 225
Tellers' Cages—Bookkeepers' Desks.

XVII ILLUMINATION DATA 231
Definitions of Terms, Units and Quantities.

XVIII MISCELLANEOUS DATA 237
Reflection co-efficients—Absorption co-efficients—Tables of co-sines—Wiring symbols, etc.

INDEX 241



HISTORY OF X-RAY LIGHTING

IN 1879 when Thomas A. Edison invented the incandescent lamp, light sources were of such low intensity that they were not particularly annoying to the human eye, and, therefore, there was little use for shades or reflectors.

Protection of the delicate mechanism of the eye from these first lamps was not then generally considered necessary. Some eminent authorities, however, even at that time, stated that exposed light sources decreased the seeing efficiency of the eye 25 per cent.

It was in 1898 that the oculists of London petitioned Parliament to pass laws against the use of unshaded electric lights, claiming that people would become blind if their eyes were exposed to such lights in streets, shops and offices.

A review of the history of electric lighting shows that efforts were almost entirely directed towards the improvement of light sources, for securing brilliant and high intensities at low cost. We are all aware of the wonderful success of these efforts.

But as electric lighting came into general use and with the lamps steadily improving in size and brightness, eye troubles and nervous disorders rapidly increased.

Early History

Development has progressed so rapidly to dazzling brilliancy, that the latest and most powerful incandescent lamps are giving, for the same consumption of electricity, 9½ times as much light as the first 16 candle-power carbon filament lamp brought out by Edison. Eye protection methods, however, developed so slowly, that eye specialists sounded many warning notes, some claiming that 60 per cent of all headaches were caused by brilliant, exposed electric lamps. That such claims were based on fact is apparent when it is noted that, in some states, laws have recently been passed prohibiting the use of exposed light sources of undue brilliancy within the range of vision.

At this acute stage of affairs the idea was originated by the engineers of the National X-Ray Reflector Company, of protection for the human eye, by a *shade*, or more properly a *reflector*, of correct design for a certain definite light control, and with the most efficient and powerful reflecting surface known to science.

To produce reflectors of exact design for the many and varied requirements of artificial lighting, it was found that peculiar and unsymmetrical shapes were necessary. In working cut the manufacture of a commercially practical article, combining all three features of (a) eye comfort, (b) light control, and (c) high reflecting power, a special glass was resorted to, which could be made in any shape that glass can be blown.

Why Named X-Ray

In February 1896, reports were first made public of the discovery by Professor Roentgen of the powerful rays of light now so familiar to us all. The invention was on the tip of every tongue, and as the new reflector, developed and perfected by Mr. E. L. Haines during this year, was productive of comparatively striking results, it was conceded that no better name could be selected descriptive of its power than *X-Ray*.

As a matter of history, it may be noted that the first X-Ray reflectors, of silvered, one-piece glass, were used for show window lighting in Chicago. The Washington Shirt Company, in 1897, installed them in their windows at the corner of Washington and Dearborn Streets, and so wonderful and unusual was the result, that a larger number were put inside the store as well. Being such an immediate success, many other installations followed, until these *show window searchlights*, as they are sometimes called, can be found in universal use. Marshall Field & Co., in 1902, purchased 1800 of the No. 696 reflector for use in their wholesale departments. This was the first important installation of X-Ray reflectors for interior lighting, and many of these original units are still in use.

Lack of space prevents a recitation of details relative to the careful development of various sizes and types of reflectors to meet growing demands. Suffice to say that today there is an X-Ray reflector available for every lighting need. Their use has been extended, both by methods of direct and indirect lighting, into the various industrial, commercial and residential fields, in fact, wherever artificial illumination is required.

Inception of Indirect Lighting

The first presentation of practicable indirect lighting was made in 1908 at the home of Mr. Augustus D. Curtis, in Chicago, before a joint meeting of the Chicago Section of the Illuminating Engineering Society and the Opthalmological Society. At this meeting the correctness of the principle on which X-Ray indirect lighting is based was clearly demonstrated.

The "Electrical World" of January, 1914, states that "The earlier meeting at Mr. Curtis' house in 1908 was perhaps the inception of the great movement of the present day for eye-comfort and the conservation of vision by concealing light sources."

From this small beginning, indirect lighting with X-Ray reflectors progressed rapidly, and was put into use so universally that it can be found at the present day in all civilized countries. This most pleasing and comfortable illumination for all classes of interiors is the result of the basic X-Ray idea. Some lands, notably the Scandinavian countries, have generally adopted this equipment and method of lighting, possibly more appreciative of its qualities because of the long hours of night which necessitate much artificial illumination.

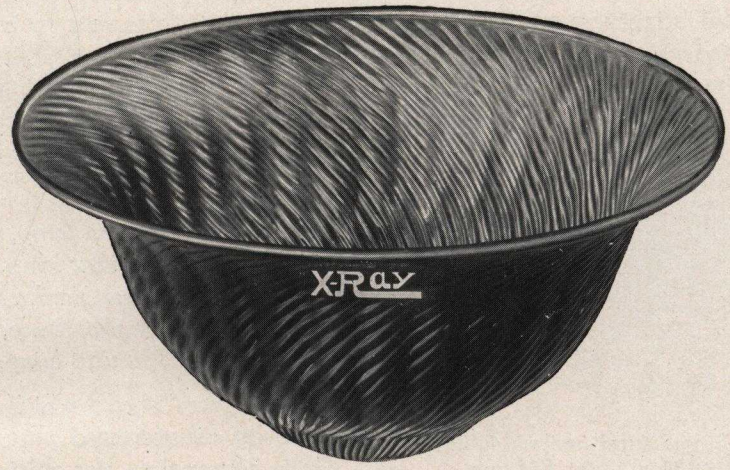
World Wide Applications

While the first applications were somewhat crude, they were, nevertheless, revolutionary. The more recent and complete details of the results secured by the use of X-Ray reflectors are presented in this book, showing the world-wide application of lighting from concealed sources.

Keeping pace with the increasing intensity of light sources, and the public demand for eye comfort, additional reflectors are continually being designed to meet new requirements.

One should not associate the idea of *Lighting from Concealed Sources* with indirect lighting alone; it applies to X-Ray direct lighting as well.

Where the light source is concealed from the range of vision,—where the light rays are controlled by directing them where needed without injury to the eye,—and where reflecting efficiency is highest,—there you will find the X-Ray reflector.



THE X-RAY REFLECTOR

FOR efficiency in directing and controlling light, and for durability, X-Ray reflectors have no equal.

The X-Ray reflector is the most powerful reflector made — the engine behind all X-Ray lighting systems. A powerful agent for proper light control which takes the light of the brilliant lamp and redirects it giving a well diffused and comfortable illumination.

This reflector is made of tough blown glass. Each reflector is of one piece. They are capable of being fashioned into innumerable shapes and sizes to conform to the wishes of the designer to secure any given distribution of light. This flexibility gives a most unusually wide range of usefulness and adaptability to the X-Ray reflector.

The reflecting surface is pure silver and is protected by a special green backing which absolutely prevents cracking, peeling or blistering.

X-Ray reflectors have the high efficiency and excellent control of light characteristic of a silvered mirror reflecting surface. This high efficiency is attributable to the high grade glass and pure silver reflecting surfaces employed, which makes absorption in the reflecting medium very low.

Because these are the most efficient reflectors available, the highest economy in supplying illumination may be obtained by their use.

Each X-Ray reflector is scientifically designed to fulfil the requirements of good lighting, to afford eye protection and to throw or direct the light of a given lamp at the most useful angle for the purposes of the light user.

Note that two distinct series of patented corrugations are employed—a spiral system and a vertical or a radial system. These are characteristic of all X-Ray reflectors. They are designed to most efficiently break up and diffuse the light rays, thus eliminating all streaks and unevenness in the lighting. Coarse, improperly designed corrugations will not give satisfactory diffusion of light, especially when the concentrated filaments of the Mazda "C" or gas-filled lamps are employed.

The marked advantage of the X-Ray reflector from the standpoint of upkeep is the ease with which it may be cleaned. The inside of the reflector is fire glazed so that the dust cannot adhere to it.

Cleaning X-Ray reflectors is a very simple matter. It is only necessary to wipe them out with a dry cloth to remove dust accumulation, and the original brightness is restored at once. The saving in maintenance and lamp breakage is at once apparent, because neither the lamp nor the reflector are removed for cleaning.

The reflecting surface itself is never touched when cleaning the reflector, as it is protected on one side by glass and on the other side by the special backing.

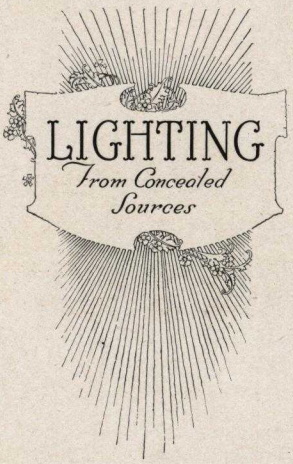
A remarkable feature of the X-Ray reflector is that it retains its original brightness and efficiency indefinitely. This results from the special processes that are used in the manufacture of these reflectors.

Fig. 1. An old type which was tested and which demonstrated the permanent qualities of X-Ray Reflectors.

In 1900, a large Chicago department store installed some 1500 X-Ray reflectors in their Carpet Department. After twelve years of daily use, one of these 1500 was sent to be tested by an entirely disinterested engineer. After the test it was returned. The old silvering was stripped off, the reflector replated making it new. It was returned, tested again, and here are the results:

Reflector with 12 year old silvering and backing.
With 60 watt lamp, efficiency 81%.
With 100 watt lamp, efficiency 83½%.
Same reflector blank resilvered and recoated.
With 60 watt lamp, efficiency 81%.
With 100 watt lamp, efficiency $84^{3}/_{10}$%.

The figures above which are taken from tests made by disinterested parties are the real proof. These figures show not only a permanent efficiency, but also the highest known efficiency—the two qualities which have made the X-Ray reflector famous.


LIGHTING
From Concealed
Sources

I ILLUMINATION FROM CONCEALED SOURCES

THE CORRECTNESS OF THE PRINCIPLE

THE trend of our artificial lighting is toward the use of larger, more efficient and vastly more brilliant units; one modern electric lamp gives as much illumination as several hundreds or thousands of candles. The candle-stick maker of olden times had very small units of light with which to work. His chief concern was to get an artistic candelabra which would accommodate candles enough to give the required illumination. Our high powered lamps are a boon but they are also a danger. We must be careful to handle them as intelligently and artistically as did the candle-stick maker of old.

We must not destroy our appreciation of the beauty of light and its influence on our sense of restfulness, in our desire to secure bright illumination.

High-power lamps should not be placed in fixtures of the old style. Although we all love the warm sun light and build our rooms with ample window area, we do not permit the direct glare of the sun in our eyes—we shade our rooms. Apply this principle to our artificial lighting also. The modern lamp has given us the means of securing ample illumination cheaply, but let us shade our eyes from the direct glare. If the unprotected eye is subjected to the intense glare of the bright lamp, it rapidly fatigues, causing strain of the ocular muscles, nervousness and headaches which incapacitate the individual and in time may cause permanent defects of vision.

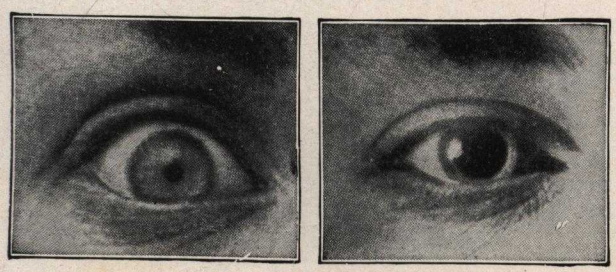


Fig. 3. The effect of light on the human eye.

The above is an actual photograph showing the terrific strain to which the eye is subjected when exposed to glare from exposed, unshielded lamps.

The eye under normal working conditions. Note the relaxed appearance which permits of comfort and constant use without danger or fatigue.

Note in Figure 3, the restricted opening of the pupil of the eye to the left which is subjected to the glaring light, and the wide open pupil of the eye subjected to shaded diffused light. More complete information on the effect of light on the eye is given on page 26, where the results of an investigation of Drs. Ferree and Rand of Bryn Mawr College are abstracted.

The day of glaring exposed lamps is passed. Now that the lamp manufacturers have brought out the brilliant gas-filled or Mazda "C" lamp, it is necessary, more than ever before, to conceal the lamp from view. X-Ray lighting equipment has been developed in order that these high-powered lamps may be used with safety.

Professor C. E. Clewell writing in the "Electrical World" states: "Extended observation on actual cases leads to the conclusion that with the greatly increased concentration of light in a very small lamp filament, there is little room for controversy in the choice of a system. With direct lighting, the difficulty of completely enclosing the filament of tungsten lamps, coupled with the general inadequacy of enclosing glassware in keeping the intrinsic brilliancy of its surfaces down to a reasonable value, makes this sytem at the present time undesirable for many office spaces.

"For similar reasons the glassware of many semi-indirect fixtures, particularly when used with nitrogen filled lamps is usually so bright that the glare in offices of ordinary height is both objectionable and harmful.

"Therefore, *lighting from concealed sources* has a number of superior features over either of the other two methods just referred to."

The following is quoted from a booklet, "Light —Its Use and Misuse," published by the Illuminating Engineering Society. "Judge the light you are getting by the way it helps you to see. Do not think because a lamp looks glaring and brilliant that it is giving you good light. It may be merely giving you too much light in the wrong place. On the other hand, a well shaded table lamp may look dim because it is well shaded and still be giving first-class light for working purposes.

"A bright light fairly in the field of view means a very brilliant light on the retina, producing fatigue. Everyone knows the blinding sensation of looking up to the sun with its sequence of dazzling colored images . . . . And when you get a bright light in the field of view, the pupil tries to shut it out; and in so doing it renders less bright things all but

invisible. Thus it is hard to see things which are nearly in line with a brilliant light, as you often find in facing an automobile headlight.

"Place an unshaded lamp in front of a picture on the wall and then stand back a few feet and note how much of the picture you can see clearly. Then hold a book or paper at arm's length so as just to cover the bright light, and note the way in which the picture clears up. Again put an unshaded lamp about a foot in front of your eyes and try to read a newspaper just beyond it. Then shade your eyes from the lamp and try it again. You will soon find out in this way that lamps can be so placed that they will be a hindrance rather than a help in seeing."

All X-Ray lighting is based upon the principle of *illumination from concealed sources*—lighting with the lamp hidden from view—a principle which is correct whether it be applied for the lighting of the store, a show window, the factory, the home or the exterior of a building.

II THE CONTROL OF LIGHT

AN EXPLANATION OF THE LAWS OF LIGHT REFLECTION AND THE APPLICATION OF THESE LAWS IN THE DESIGN OF LIGHTING EQUIPMENT

LIGHT uncontrolled is as useless as an unharnessed Niagara. It is not only unsuited to our pupose, but is often obnoxious to the human eye.

The difference, between exposed lamps and indirect illumination may be likened to the difference between a single, overpowering, strong stream of water from a hose, and a fine, gentle spray from the same nozzle. The heavy stream of water tears up the lawn and flowers, the gentle spray helps them thrive. It is the same stream of water differently controlled. In one instance it destroys and in the other it benefits. So, in lighting, powerful glare injures eyesight, while softened, evenly diffused illumination is restful and soothing.

An application of the fundamental laws of light is made in the designing of every type of X-Ray reflector. We are all familiar with the primary law of reflection as explained in our high school physics text books, that the angle of reflection is equal to the angle of incidence. In other words, light rays striking a reflecting surface leave it at the same but opposite angle. The primary law is illustrated in Figure 5, where a is equal to a'. The incident ray makes the angle a with the normal line, and the reflected ray makes the angle a' with the same line. All light rays striking a polished reflecting surface follow this law.

There are other laws that govern the reflection of light. The effect of the operation of these laws is illustrated in Figures 7, 8 and 9 on next page. Light reflected as in Figure 5 is governed by the law of regular or specular reflection. Light reflected as in Figure 7 is governed by the law on spread reflection, while Figure 8 illustrates a ray of light governed by the law of diffuse reflection. It will be noted that in the first figure all of the reflected light travels in the same direction and in the second figure most of the light that is reflected, travels in the same general direction, but a portion of it spreads at angles to the surface upon which the light strikes.

Such surfaces as mirrors and polished surfaces follow the law of regular reflection. Glass and rough

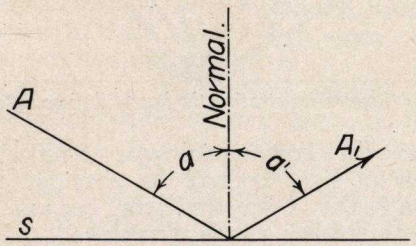


Fig. 5. Diagram illustrating the primary law of light reflection—regular reflection.

metal surfaces follow the law of spread reflection, while diffuse reflection occurs when a ray of light falls upon opal glass, porcelain enamel or painted and calcimined surfaces.

It is by following the above principles and rightly shaping the reflectors that the light rays are controlled and distributed with absolute accuracy with X-Ray reflectors. The great range of control of light with X-Ray reflectors is illustrated in Figure 10. One diagram shows the light projected into a powerful beam with candle power values that are up in the thousands. The other extreme is indicated by another diagram which shows how the light is reflected at wide angles in many directions. Both of the above results and all of the intermediate degrees of spread of the light are readily accomplished with X-Ray reflectors.

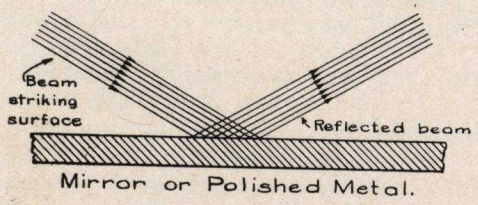


Fig. 4. Reflection of a beam of light from a polished surface.

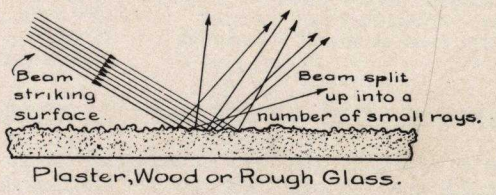


Fig. 6. Reflection of a beam of light from a rough surface.

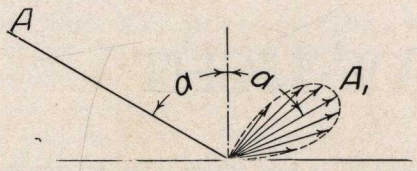


Fig. 7. Diagram illustrating the law of spread reflection.

X-Ray reflectors are made in many shapes. Some are symmetrical in their design, others non-symmetrical; some are peculiarly fashioned and control the light in a definite and given manner, depending upon the work the reflector is intended to perform.

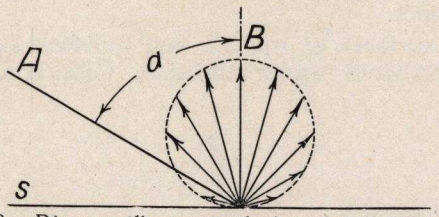


Fig. 8. Diagram illustrating the law of diffuse reflection.

With no other commercial type of reflector can the degree of light control be obtained that is secured with the X-Ray reflector, because of the nature of the reflecting surface employed. A high degree of control can be obtained with polished metal surfaces, but these are impracticable because of the fact that they tarnish when exposed to the air. The X-Ray reflector is the nearest approach to a highly polished silvered surface. The peculiar advantage of the X-Ray reflector is that its brilliancy is not affected by atmospheric conditions which corrode the polished metal surface.

Glass, rough metal surfaces, opal glass, porcelain enameled and painted surfaces, do not give a wide range of light control. The X-Ray reflector can, therefore, be applied to many uses where accurate results are required and where other types of reflectors would be entirely unsuitable.

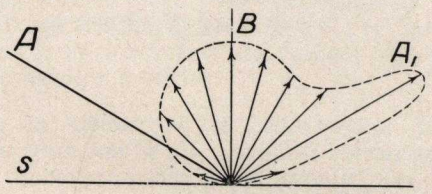
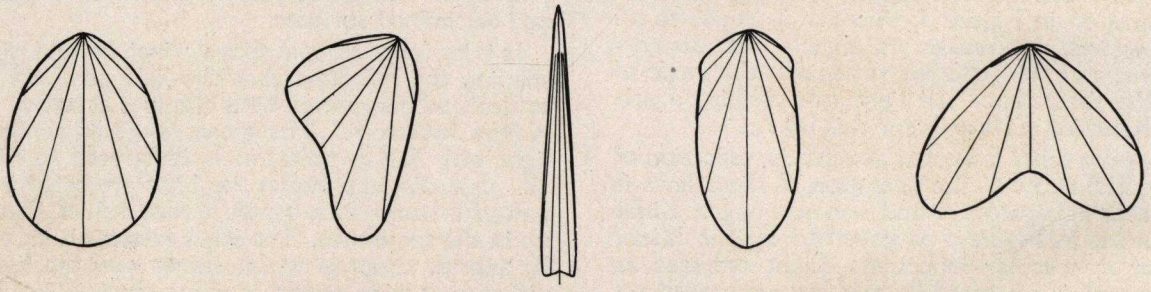


Fig. 9. Diagram illustrating law of spread and diffuse reflection combined.

Mr. Thomas W. Rolfe in a paper before the Illuminating Engineering Society, makes the following statement: "It is apparent from the nature of these types of reflection of light, that regular or specular reflection will control light most accurately. A perfect mirror or a polished metal surface is absolute in the control of the light which it reflects. A small portion of a light enters the surface, but the remainder is reflected in directions which can be governed accurately . . . . "

We can account for the wonderful control of light with the X-Ray reflector equipment by the fact that the equipment is designed in strict accordance with the laws of light reflection.



How light is controlled with X-Ray Reflectors.

Fig. 10. These diagrams are illuminating engineers curves which show how light is controlled by X-Ray Reflectors of various shapes—all of which, however, hide the lamp. The X-Ray Reflector is the only one in commercial use which can be designed in different shapes to concentrate the light in a small spot and also give a wide spread of illumination—absolute control of light.

III INDIRECT LIGHTING

GENERAL PRINCIPLES

THE idea of X-Ray indirect illumination came from the request of a sick woman to have the light which shone into her eyes inverted. The X-Ray reflector with which this light was equipped sent the light to the ceiling where it was diffused, lighting the room adequately but without the ill effect of the light glaring directly into the eyes. Working from this incident, the National X-Ray Reflector Company has developed a great field of indirect illumination and applied the science of good lighting to all kinds of interiors, emphasizing that *illumination*, not fixtures, is now the basis upon which all lighting is judged.

Comfort, adequacy and the highest artistic effects are found in the X-Ray indirect lighting system. X-Ray reflectors produce what everyone wants—a light that rivals sunlight. Science has found that only by the proper direction and diffusion of light rays, can the sun be rivaled. Not brilliancy, but the clear glow of daylight is reproduced by indirect illumination.

Experience in making thousands of installations, numerous exhaustive tests by those in the lighting business, as well as by many of the largest companies in this country, who have adopted indirect illumination, have proved that the following essentials found in the X-Ray Reflectors are necessary for economical and completely successful indirect lighting:

First:	The use of most powerful reflecting surface in the reflector.
Second:	Scientific design of the reflector.
Third:	Permanent efficiency of the reflector.
Fourth:	Low maintenance cost.
Fifth:	Correct engineering practice.
Sixth:	Correct ocular practice (not necessarily high light intensity) resulting in greatest eye efficiency, which naturally means Human Efficiency.
Seventh:	Variety and harmony in fixture design.

Indirect lighting as exemplified by the X-Ray system, is essentially *illumination from concealed sources*. The light flux from the primary light source—the lamp—is directed to the ceiling, a relatively large area, which in turn reflects it back into the room and in this capacity acts as a secondary light source.

The resultant illumination is characterized by absence of high brilliancy light sources, great uniformity of illumination and excellent diffusion, which eliminates sharp shadows and specular reflections or glare from glossy surfaces.

No other form of illumination adds so greatly to the comfort of the individual when working under artificial light. The uniform and diffuse illumination is very restful to the eye and several hours work under it causes practically no fatigue. A scientific investigation of eye fatigue is given on page 26.

No other form of illumination is a better paying investment to the employer; the employee is able to work more expediently, he makes fewer mistakes and since he is working under hygienic conditions, his services and good will are retained. All of these considerations result in a maximum human efficiency, which in these days of high wages are just as important as machine efficiency.

No other form of illumination adds so greatly to the artistic appearance of an interior. It brings out the architectural features as a harmonious whole, most beautifully. Many modes of treatment make possible the design of lighting equipment which will blend in with the architecture of the interior and frequently be a part of it.

The following is taken from *Scientific American*, September 22, 1914; "Best Light for the Eyes":

"Some three years ago the American Medical Association appointed a special committee to make a study of the effect of different lighting systems on the eye. The problem of lighting, as treated by engineers, has been for the most part an attempt to discover the most efficient forms of lighting from the point of view of economy—that is, how to get the most illumination for the least expenditure of energy. The problem of this committee has been to discover the form, distribution, intensity, and the quality of light from the point of view of the health of human eyes.

"Of the systems of artificial illumination, the so-called indirect is the best. In this system, the source of light is concealed from the eyes, the light being reflected to the ceilings or walls, and from these to the working surface. In direct illumination, there is always the danger of having extremely bright spots in the illuminated surface. A system called the 'semi-indirect' was found to be little better for the eye than the direct system. In this, the light is thrown to the ceiling or walls, as in the indirect system; but part of the light is allowed to come through translucent shades.

"For daylight and the indirect system, a wide range of illumination allows the eye to continue its work for several hours without undue strain, or rather without considerable falling off in efficiency. But with the semi-indirect and the direct systems, there is evidence of fatigue at every intensity of illumination."

INDIRECT ILLUMINATION IS ECONOMICAL

Indirect illumination properly installed is economical and efficient. It costs no more than adequate direct lighting. Its production requires accurate engineering knowledge in the design and installation

of the system, plus scientifically designed reflectors which will control the light rays and spread them evenly over the entire room from a uniformly lighted ceiling. Indirect lighting fixtures which give a dim uneven light and a poor ceiling illumination lack proper reflectors. The satisfactory production of indirect lighting rests primarily with the correctly designed reflectors within the bowl. It has nothing to do with the shape or design of the bowl of metal or glass or whatever it may be that encloses and conceals the reflector. A $10.00 fixture will produce just as perfect lighting as a $100.00 bowl. Both are equipped with the same kind of X-Ray reflector.

X-Ray indirect lighting conforms to the requirements of perfect illumination; it provides better working and living conditions; it lessens eye strain, defective vision and need for glasses. It eliminates glare from lamps, glazed paper, etc. It makes desk lamps unnecessary. It eliminates deep shadows and dark corners. It uniformly lights the entire interior, making every square foot of floor space available. It is undeniably artistic and at the same time eminently practical.

LIGHTING METHODS

The lighting methods now employed fall into three general classes—direct lighting, semi-indirect lighting and indirect lighting.

Direct Lighting

Direct Lighting is the usual and more commonly employed method. It consists of hanging bare lamps or lamps shaded by reflectors in such a manner that most of the light is directed downward upon the desks and tables. With bare lamps, there is, of course, no attempt to control the light and much of it is lost on the side walls and ceiling. Greater efficiency is obtained by placing on the hanging lamp a shade, reflector or enclosing globe. Unless the reflectors are carefully designed to shade the lamp, much glare results from the direct lighting system.

Semi-Indirect Lighting

The *Semi-Indirect Lighting* system is characterized by a fixture of the glass bowl type and containing bare lamps. A portion of the light is reflected to the ceiling by the interior of the glass bowl. The remaining portion is transmitted through the bowl causing the bowl in many cases to appear brightly lighted.

Many of the glass bowls employed for semi-indirect fixtures transmit too large a percentage of the light directly through the bowl. This intense brightness is injurious to the eye, especially when the Mazda "C" or gas filled lamps are employed.

Many glass bowls have beautifully etched designs and some are artistically tinted. When these bowls are moderately illuminated, the decorations are strikingly revealed, whereas, when intensely illuminated, the decorations are partially if not entirely obliterated. Therefore, artistic considerations also demand low brightness of the bowl.

As aptly stated in a recent article in "House & Garden" "the mere grouping of bare lamps, within one glass bowl, *is at best a miserable compromise betwixt direct and indirect lighting.* This is because the inner surface of the glassware generally used has a negligible reflecting or diffusing action, and in practically all instances the light sources are stupidly placed so that their effective distribution cannot be efficiently utilized in producing the desired effect."

Below a special equipment is described which can be used in any glass bowl of a semi-indirect fixture to give efficient indirect illumination, and at the same time light the glass bowl of the fixture to a brightness which is considered good practice.

Indirect Lighting

X-Ray Indirect lighting has been previously described as consisting of a system in which the ceiling or walls of the room are employed to redirect the light into the room. Efficient indirect lighting is obtained only with X-Ray reflectors. Each lamp has its individual reflector. This reflector is the corner stone of efficient indirect illumination. It utilizes the maximum of the illumination of the lamp.

The application of the indirect lighting system is not confined to the use of the fixtures hanging from the ceiling. Beautiful indirect lighting effects can be obtained from urns, cornice and cove sidewall brackets, art lamps and in many other ways described in Chapter VI.

THE LUMINOUS BOWL PRINCIPLE

The X-Ray luminous bowl fixtures are truly indirect and not to be confused with so-called semi-indirect. Just as in the opaque indirect fixture of metal and compone each lamp is equipped with an opaque reflector for the purpose of directing the light rays against the ceiling at the correct angle thus insuring perfect indirect illumination. When several lamps and reflectors are used in the bowl, provision is made for a small lamp, the only function of which is to illuminate very softly the glass bowl or panels in the fixtures. When but one lamp and reflector are used, a cup of translucent opal glass is set into a hole at the bottom of the reflector as in Figure 13, permitting a small percentage of the light to pass through and evenly illuminate the bowl without spots of light and shade.

With this method, the bowl is not glary, harsh or obtrusive, no matter how bright the lamp may be. Its faint glow casts no objectionable shadows nor

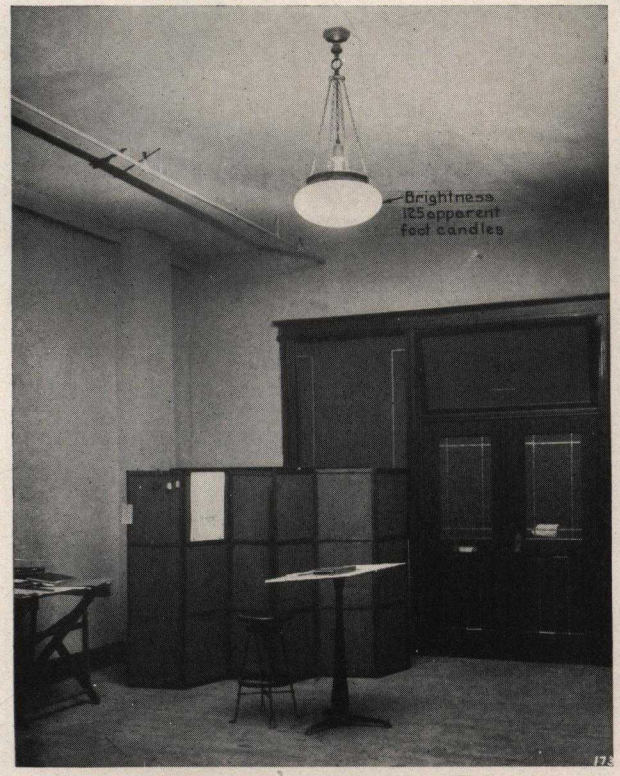


Fig. 11. With X-Ray Equipment.

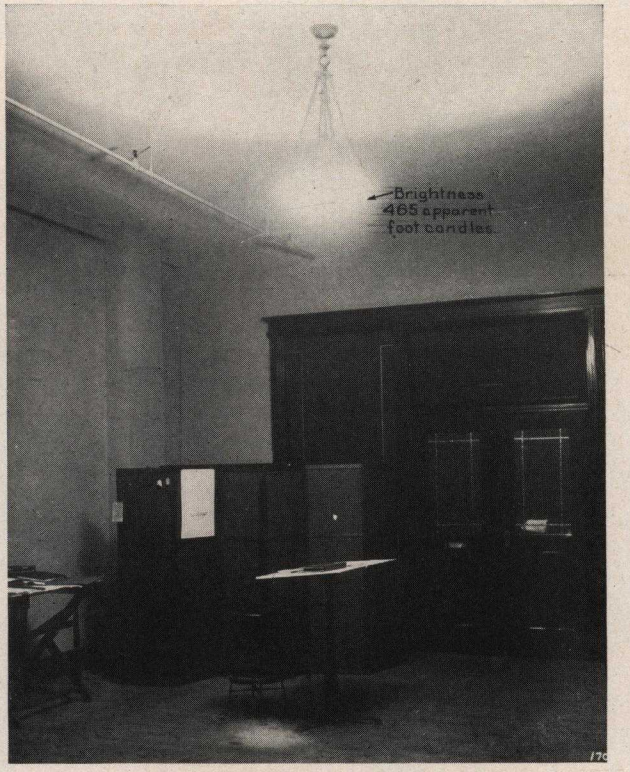


Fig. 12. Without X-Ray Equipment.

Two night photographs taken identically the same as regards camera, exposure, fixture and lamp.

does it ruin the beautiful indirect illumination which is so essentially an illumination from concealed sources. In short, the luminous bowl X-Ray indirect lighting fixtures possess artistically lighted bowls and do not sacrifice the indirect effect originally sought.

Above two night photographs are shown of a fixture equipped with an X-Ray reflector-diffuser and without the reflector-diffuser unit. These photographs were taken under identical conditions as regards to camera, exposure, fixture and lamp.

Note in the picture at the right, the glare and brightness contrast of the bowl of the fixture. This is the condition of many of the semi-indirect lighting installations. The human eye should not be compelled to endure conditions of this character when by simply employing special X-Ray equipment the effect shown in the picture at the left can be obtained.

In the picture at the left, there is small brightness contrast. Under these conditions the eye functions with minimum loss of efficiency or seeing ability. The shadows are softened and the illumination in the room is much more evenly distributed.

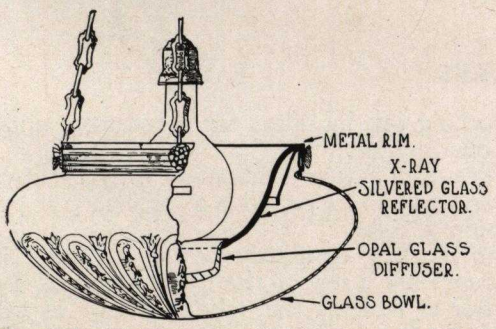


Fig 13. Reflector-diffuser installed in ornamental glass bowls.

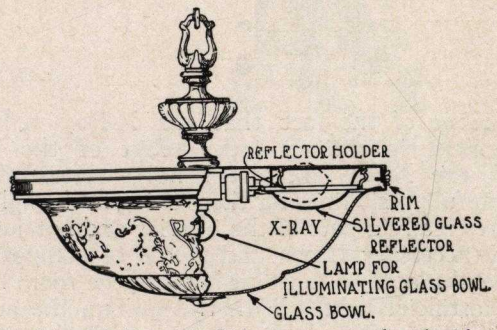
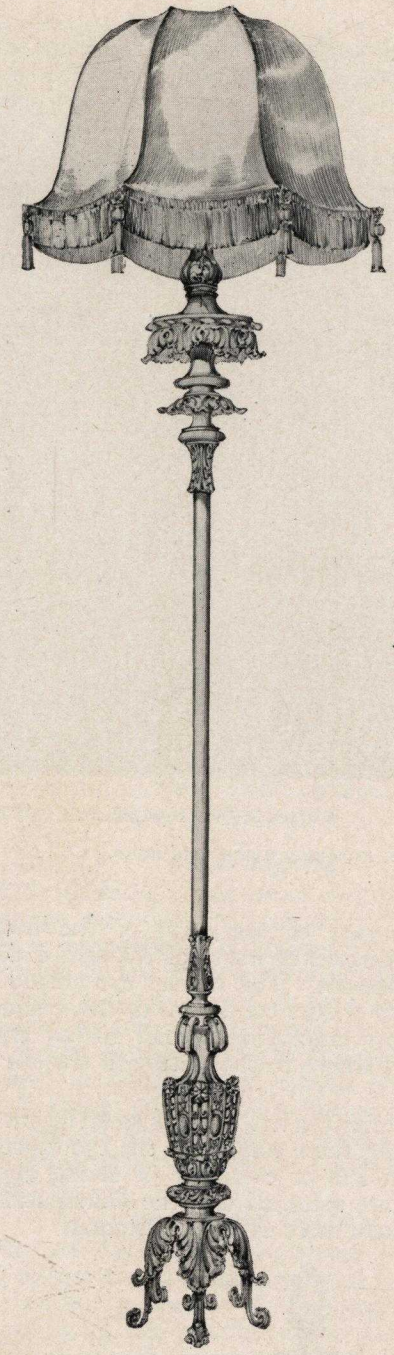
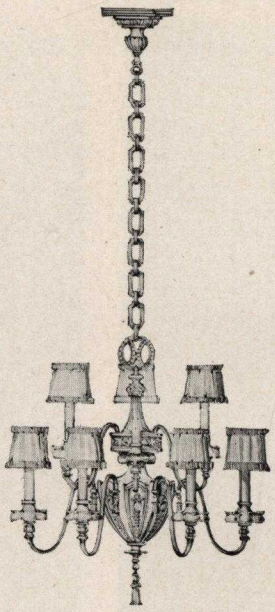
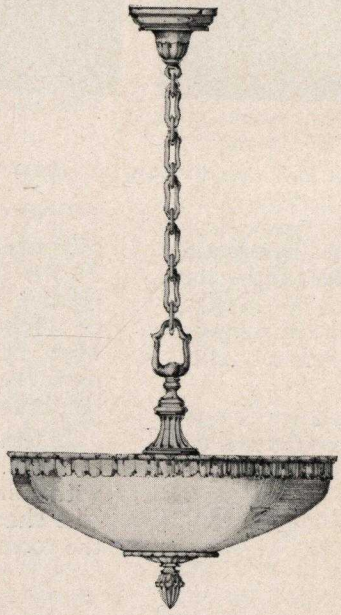


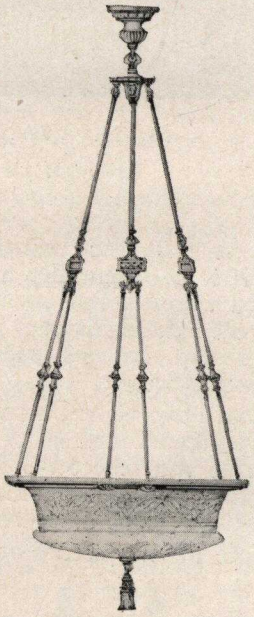
Fig. 14. Multi-unit reflector equipment for glass bowls.





All containing X-Ray Reflectors for indirect lighting.



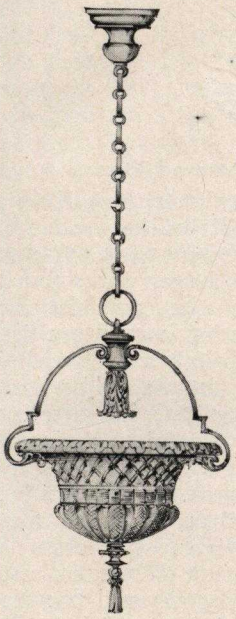


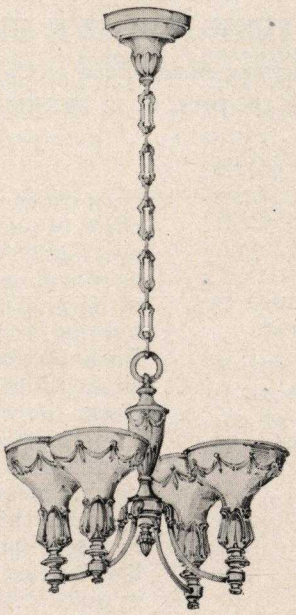
ARTISTIC FIXTURES

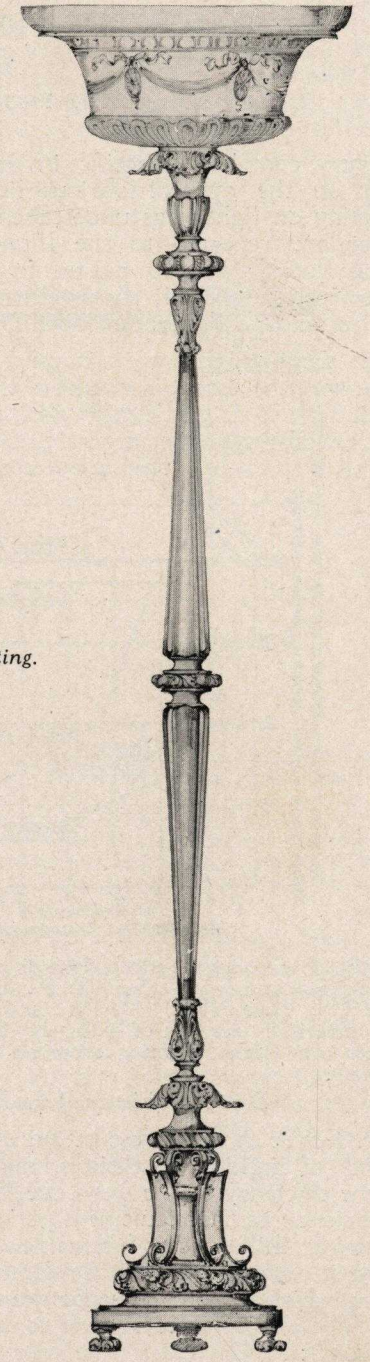
Because of the fact that the X-Ray reflector equipment is entirely independent of the bowl itself, the X-Ray indirect lighting system offers wonderful possibilities for the making of the lighting fixtures really a part of the interior and not just so many necessary lamps and pieces of composition or metal placed in position because the room must have artificial light. With this system the artist, architect or interior decorator is entirely unhampered in working out his ideas for a complete and harmonious interior.

A beautiful fixture in harmony with its surroundings and true to its period is as necessary as perfect diffusion of light.

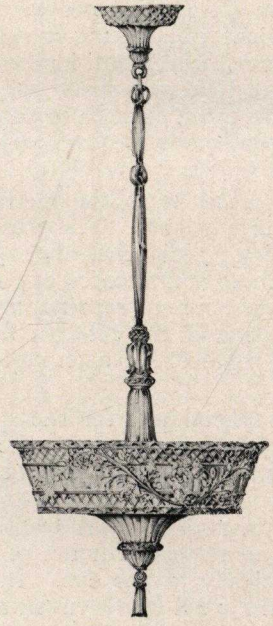
The fixtures designed shown on these pages illustrate only a few of the interesting and artistic methods of treating the lighting fixture as worked out by the fixture designers.

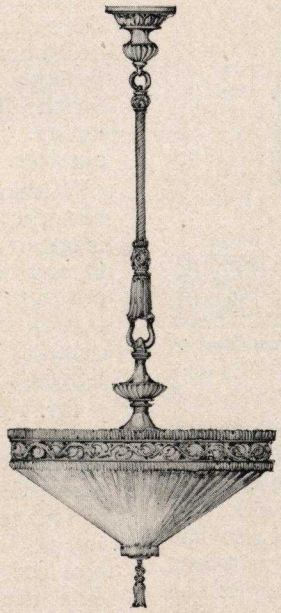






All containing X-Ray Reflectors for indirect lighting.





FLEXIBILITY

The X-Ray indirect lighting system has been aptly termed the most flexible system of illumination ever conceived.

It is to be found in beautiful churches, finely equipped offices, country clubs, up-to-date hospitals, luxurious homes, well lighted theatres, stores, banks, hotels, libraries, public buildings and even in the workrooms of industrial plants. It is not only employed in the usual opaque or luminous bowls, but beautiful effects can be secured from other concealed sources—such as, pedestals, urns, coves, wall brackets and floor lamps. X-Ray indirect lighting is adaptable to practically any lighting scheme or arrangement. It is not only an acknowledged success from the physical and physiological standpoint, but is equally successful in an artistic way—a happy combination harmonizing the art and science of lighting.

THE FERREE TEST FOR EYE EFFICIENCY

Indirect Lighting Almost Equal to Daylight

FACTS FROM TESTS OF DRS. C. E. FERREE AND G. RAND

A very complete scientific investigation of the effect on the eyes of various lighting systems, including daylight, was undertaken by Dr. C. E. Ferree and reported to the Illuminating Engineering Society in two papers in 1912 and 1913 respectively. In 1914, the work was continued by Dr. Ferree in collaboration with Dr. G. Rand.

The scope of this work is very comprehensive, hence only the essential results of this investigation which have to do particularly with the loss of efficiency of the eye, after a period of work under the various systems of illumination, are given.

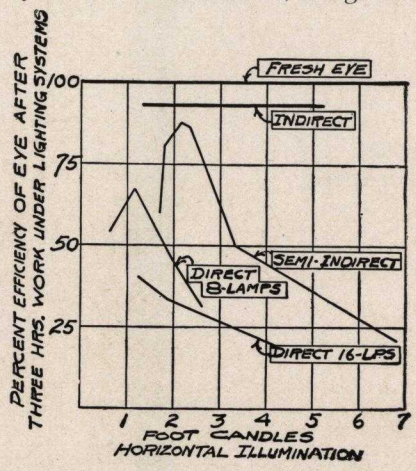


Figure 15. Showing the effect of the distribution factors on the efficiency of the eye. (See Ferree and Rand: Efficiency of the Eye, Chart VIII.) Daylight and Indirect Lighting cause practically no loss of efficiency of the eye. Semi-indirect and Direct Lighting cause an enormous loss of efficiency.

Loss of Efficiency of the Eye

Dr. Ferree in his investigation of the numerous aspects of lighting conditions, made a study of, (1) the efficiency of the fresh eye, and (2) the loss of efficiency as the result of a period of work. In beginning this series of tests to investigate the above, it was necessary to determine the important factors which tend to influence the efficiency of the eye. These, Dr. Ferree has singled out and classified as follows:

(1) Distribution Factors
  (a) Evenness of illumination.
  (b) Diffuseness of illumination.
  (c) Angle at which light falls on objects viewed.
  (d) Evenness of surface brightness in field of view.
(2) Intensity of illumination.
(3) Quality of illumination (Color).

Effect of Distribution Factors

In order to obtain results which would show the effect of variation of the distribution factors on the eye, factors (2) and (3) were kept as nearly constant as practicable and tests conducted under four types of lighting in common use, i. e., daylight, indirect lighting, semi-indirect lighting and direct lighting. Each of these systems of lighting give different characteristic distribution factors. For instance, direct lighting is characterized by extremes of brightness differences and a high ratio of the brightness of objects in the field of view to the brightness at the point of work. With semi-indirect lighting, this effect is much less marked and with indirect lighting and daylight, still less. Direct lighting has but a fair degree of diffuseness resulting in quite sharply defined shadows and the glare of specular reflection. Semi-indirect lighting has a somewhat higher degree of diffuseness and indirect lighting and daylight, still more diffuseness.

The conditions under which the tests were conducted are quite typical of lighting conditions designated by the terms, direct, semi-indirect and indirect. The quality of light was made the same for the three systems by using clear bulb tungsten lamps. The intensity was made as nearly equal as possible.

Without going into detail as to the method of test the procedure is briefly this: The fresh eye is tested under the lighting system; then the observer is required to read for three hours seated at the test position. After the three hours of reading, another test of the eye is made and the relative fatigue determined. This was repeated for each system of lighting.

Dr. Ferre devised a special test for the specific purpose of measuring the efficiency of the eye. It has proved very successful, and gives consistent results.

The results of these tests are shown graphically in Fig. 17. The abscissae represent hours of time, and the ordinates, efficiency of the eye. In each case, the efficiency of the fresh eye is taken as one hundred per cent for comparative purposes. It will be noted that with daylight and indirect lighting, the eye loses practically nothing in efficiency after three hours of work, whereas for direct and semi-direct illumination the eye loses enormously in seeing efficiency. In other words, these latter systems cause rapid and heavy fatigue.

In order to determine the effect of relative distribution and number of bright surfaces (particularly lighting units) in the field of view, similar tests were run at different positions, for the three

artificial systems of lighting. The results of these tests are shown in Fig. 16. The abscissae represent test positions, and the ordinates, efficiency of the eye. In position 1 six lighting units were in the field of vision; position 2, four units; position 3, two units; and in position 4, no unit in view.

For position 1, it will be noted that practically the same relative loss in efficiency exists for each system as shown in Fig. 17. However, as the number of bright surfaces (particularly lighting units) is diminished in progressing from positions 1 to 4, the relative fatigue or loss in efficiency of the eye for the semi-indirect and direct systems decreases, whereas for the indirect, it remains practically constant. Even at position 4, the direct and semi-indirect systems show a much more marked loss of efficiency of the eye, than the indirect, although in this position the ratio of the brightest surfaces in the field of view to the brightness of the test card is not markedly different for all three systems. This indicates that the other causes enumerated under distribution factors are contributing to this deficiency of direct and semi-indirect systems.

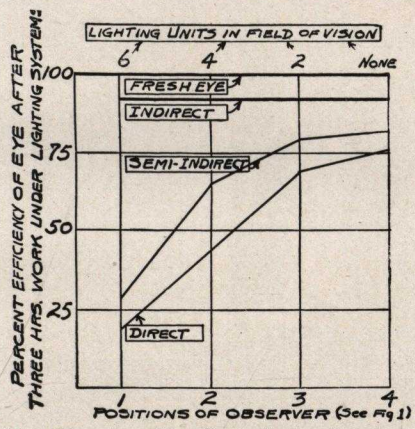


Figure 16. Showing the effect of the distribution factors and the position of the observer in the room on the efficiency of the eye. (See Ferree and Rand: Efficiency of the Eye, Chart No. I.) With the indirect system there is but little loss in efficiency and the results are practically independent of the position of the observer. With the semi-indirect and direct systems the loss in efficiency is greater and depends very much upon the position of the observer.

Effect of Intensity

In order to find the effect of the intensity of illumination on the eye and the most favorable intensities for least loss of efficiency, the factors 1 and 3 (distribution and quality) were kept as nearly constant as practicable, and tests made with various intensities of illumination for each of the three systems. The tests were made in the same room with the same fixtures, and under identical conditions. To secure the various degrees of intensity required, lamps of different wattages were used and in this manner the quality of light kept the same. In order to keep the distribution of illumination and brightness of surrounding surfaces as nearly constant as possible, the lamps used for any particular system were all of the same size, i. e., all 15-w, 25-w, 40-w, etc. In order to secure relatively the same distribution of light from the smaller lamps, socket extenders were used in order to bring the lamps in their proper relation to the reflectors. Tests were made only at position 1, in which position six lighting units were in the field of view.

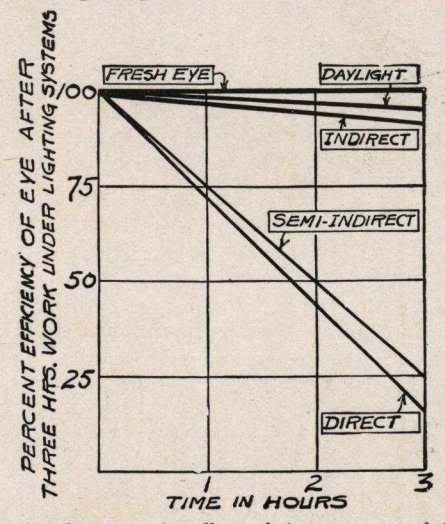


Figure 17. Showing the effect of the intensity of illumination on the efficiency of the eye. (See Ferree and Rand: Efficiency of the Eye, Chart II.)

With the indirect system the loss in efficiency is very low and is practically the same for all intensities. On the contrary, with the semi-indirect and direct systems, the loss of efficiency of the eye increases rapidly with the intensities (2.5 to 8 foot-candles) ordinarily employed.

These results are given in Figure 15. They show that for indirect lighting, the loss of efficiency is very low and that it is practically constant for all intensities ordinarily encountered in practice; that with direct and semi-indirect lighting systems, the loss in efficiency is very great, except for a very limited range of intensities (1.75 to 2.5 for the semi-indirect and 1.0 to 1.5 for the direct) and that the intensities between these limits are too low for most purposes of work.

Conclusion

These tests confirm the opinion held by many that the eye does not lose very much in efficiency as the result of several hours' work under daylight. They confirm what the National X-Ray Reflector Company felt confident of—i. e., (1) that indirect lighting is the nearest approach to daylight and (2) that to all intents and purposes the semi-indirect and direct systems may be classed together, in so far as their effect on the efficiency of the eye is concerned, and that they cause very great eye fatigue.

It is further shown that with the indirect system the loss of efficiency of the eye is not only practically negligible, but also is practically independent of the position of the observer, and the intensities of illumination ordinarily employed.

Fig. 18. St. Helena Cathedral, Helena, Montana, A. O. Von Herbulis, Architect, Birmingham, Alabama
(See also page 113)

IV PLANNING INDIRECT LIGHTING

EQUIPMENT AND METHODS OF FIGURING

INDIRECT lighting has come to stay. All scientific investigations into its merits tend more and more to confirm the belief long ago expressed by its advocates that it is the most comfortable light for the eyes since it is the nearest approach to daylight in diffusion and uniformity. Its wider application has been greatly hastened by the constantly increasing efficiency of light production by the incandescent lamp. This increase in efficiency has been accompanied by even greater increases in brilliancy of the light sources, making radical changes in the lighting equipment and methods absolutely essential. Illuminating engineers and people in general realize that indirect lighting is the most fool-proof in its insuring proper eye protection. Furthermore, the high efficiency of the lamp now makes it reasonable in cost of operation.

In the indirect lighting system, the light flux of the lamp, the primary light source, is reflected to the ceiling and walls which becomes the secondary source of illumination. The useful illumination on the reference plane, tables and benches is derived solely from the reflected light from the ceiling and walls.

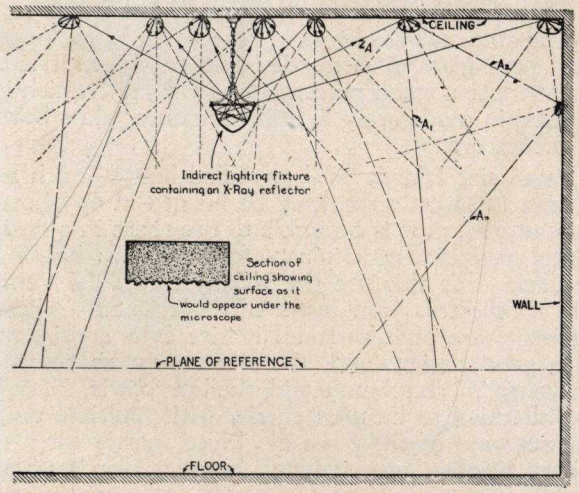


Fig. 19. Illustrates the manner in which an indirect lighting unit delivers the light rays to the ceiling and how these are reflected as a diffused illumination throughout the room.

In Figure 19 is illustrated graphically the method by which the light is reflected and re-reflected from the ceiling and walls. The light ray "A" striking the ceiling is broken up and reflected in numerous directions as shown. Some of the reflected rays, as for instance, A1, are reflected directly to the plane of reference, whereas other rays, as for instance, A2, are reflected to the walls, where they are broken up and re-reflected in a similar manner. Some of these rays, like A3, are reflected to the plane of reference, while others are reflected to the ceiling or opposite wall, and undergo the same process. With well designed equipment, light ceilings and walls, really surprising efficiency may be secured.

In the planning of an indirect lighting system, while the characteristics of the light source play an important part, knowledge of other factors is also necessary. In fact, what we are most concerned with are ceilings and walls; since these are the effective light sources, they completely alter the conditions. Heretofore, with the direct lighting system, the light source was relatively very small and comparatively distant from the surface to be illuminated. With indirect lighting, conditions are reversed. The effective light source is large in area, and, is comparatively close to the plane of reference.

CLASSES OF INTERIORS SUITABLE FOR INDIRECT ILLUMINATION

For purposes of convenience in designing the indirect lighting system for interiors, these interiors are divided roughly into three classes:

Class No. 1: This class embraces interiors of the commercial type, in which a uniform general working illumination is required, and includes the following: Offices, hotels, clubs, banks, libraries, stores, shops, display rooms, schools, barber shops, and factories where indirect lighting is used. The practical application of the X-Ray indirect lighting system for the above interiors is taken up in detail on pages 39 to 56.

Class No. 2: This class includes those interiors in which a great uniformity and diffusion of light is required ordinarily with a high intensity. Its examples are to be found in drafting rooms, operating rooms, and large sewing rooms. See pages 57 and 72 for discussion of the application of X-Ray indirect lighting to these interiors.

Class No. 3: Interiors wherein the artistic and aesthetic play an important part are included in this class. Uniformity of illumination is not so essential here, but is many times sacrificed to the artistic. Many interiors designed for purposes of amusement, entertainment, and education are included in this class. The more important ones

are—ball rooms, writing rooms, restaurants, lobbies, lodge rooms, churches, auditoriums, hospitals, railway stations, residences, theatres, and public buildings. For a full discussion on the application of indirect lighting of these interiors, see pages 59 to 77.

It will be noted from the above that the classification is made not with reference to the class of building under consideration, but rather on a basis of the quality and intensity of light required. It is frequently the case, therefore, that in considering the lighting of a building we will find rooms which fall into two or three of the above classes, as for instance, a school building. The class room would be considered under class No. 1, the drafting room under class No. 2, while the assembly hall would fall under class No. 3.

X-RAY EQUIPMENT FOR INDIRECT LIGHTING

The success or failure of any installation of indirect illumination depends basically on just three things:

1. The reflector that is used with the lamp.
2. Light-colored ceiling.
3. Regular upkeep of the fixtures and decorations.

As a light-colored ceiling is the reflecting surface which diffuses the light throughout the interior, the intensity of illumination produced in the room using a given amount of current depends on how much light really gets to the ceiling to be diffused. The only way to direct all the light possible against the ceiling is to use the most powerful reflector made.

Scientifically designed reflector equipments and accessories have been developed to meet the requirements for indirect illumination from ceiling fixtures of many types, floor pedestals, urns, portable floor and table art lamps, wall and pillar brackets, column capitals, and cornices. This equipment has been standardized and requisite information on the various types of reflector equipment is given herein.

With this data at his command, the architect, the lighting man, or contractor can plan fixtures to harmonize with the specific interior, and be assured that the illumination will be ample in quantity and perfect in quality, and the combined artistic and lighting effect entirely in accord with the general period or scheme of decoration.

X-RAY REFLECTORS FOR MAZDA "C" LAMPS

The new Mazda "C" gas-filled lamps have made possible more and better lighting for less cost. They have put indirect lighting within reach of everyone. However, the introduction of these lamps presents new problems to be solved by the lighting engineer and designer. Their increased efficiency is accompanied by much higher temperature. The intrinsic brilliancy of the lamp is many times that of the old style lamp and the construction and method of mounting the lamp filament is such that we have almost a point source of light. All of these things combined require the design and development of the new reflectors. The EC series of X-Ray reflector for indirect lighting shown on the next page is designed especially for these lamps. The contours of these reflectors are such as to broadly distribute the light over the ceiling in a uniform and agreeable manner and at the same time secure greatest efficiency of light utilization.

They are made more distributing than the indirect lighting reflectors formerly produced. This is a very desirable feature, because the increase of efficiency of gas-filled lamps makes possible lighting larger areas than formerly by means of a single fixture.

The EC reflectors are made with a high temperature backing which successfully resists the temperatures developed by the lamp. The dual system of coarse radial and fine spiral corrugations breaks up and disperses the light to entirely eliminate streaks and striations on the ceiling. Where these reflectors are constructed without the specially designed corrugations, the illumination on the ceiling would present a very spotted and streaked appearance.

The *luminous bowl type* of reflectors are equipped with opal glass diffusers designed to transmit and redistribute a small percentage of the light which is utilized in moderately lighting the outer glass bowl of the fixture.

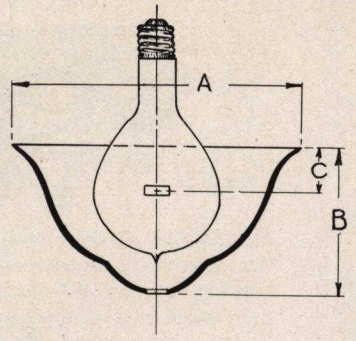
Small size Mazda "C" gas-filled lamps—such as 75 and 100 watt sizes, may be burned in any position, and often it is desirable to use them in a horizontal position, particularly for residence lighting fixtures. For this use the X-Ray E60, EC71 and E155 reflectors are especially designed. These reflectors are built as small in size as is consistent with good design, and, therefore, may be accommodated in very small and shallow bowls. They are intended to be used chiefly with multiple unit fixtures, and as these are employed mostly for low ceiling heights, are designed broadly distributing.

LAMPS

The lamps which are available for use with X-Ray indirect lighting equipment are rated in watts and can be obtained in sizes varying from 10 watt to 1000 watt. With indirect lighting clear bulb lamps only should be used. A table is given on page 35 wherein the various lamp sizes are listed, and information pertaining to them is given.

REFLECTORS FOR EFFICIENT INDIRECT LIGHTING

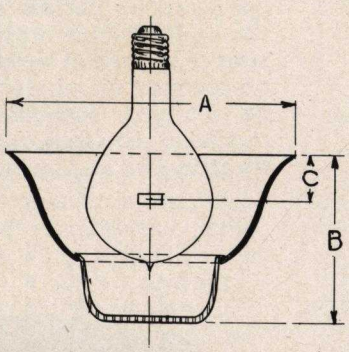
For tip-down use in Opaque Bowls.



FOR TIP-DOWN USE IN OPAQUE BOWLS.

REFLECTOR NUMBER.	SIZE OF LAMP IN WATTS	DISTANCES A	B	C	TYPE OF LAMP.
EC-12	100-200	$9\frac{1}{2}$"	$4\frac{13}{16}$"	$1\frac{13}{16}$"	MAZDA "C"
EC-345	300-400-500	12"	$6\frac{1}{8}$"	$1\frac{7}{8}$"	" "
EC-751	750-1000	16"	$7\frac{7}{8}$"	$2\frac{3}{8}$"	" "
E-40	40-50-60	$6\frac{1}{2}$"	$2\frac{9}{16}$"	1"	MAZDA "B"
E-15	25 W.G-18$\frac{1}{2}$	$4\frac{1}{4}$"	$1\frac{13}{16}$"	$\frac{9}{16}$"	" "

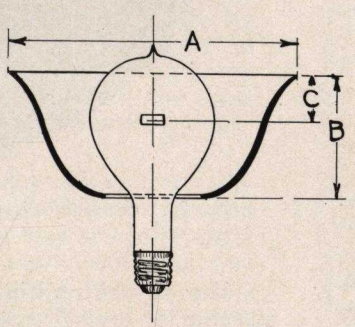
For tip-down use in Luminous Bowls.



FOR TIP-DOWN USE IN LUMINOUS BOWLS.

EC-14	100-200	$9\frac{1}{2}$"	$5\frac{3}{4}$"	$1\frac{13}{16}$"	MAZDA "C"
EC-346	300-400-500	12"	$6\frac{7}{8}$"	$1\frac{7}{8}$"	" "
EC-758	750-1000	16"	$8\frac{3}{4}$"	$2\frac{3}{8}$"	" "

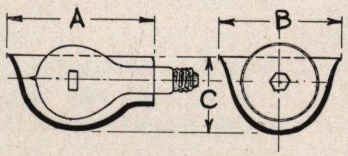
For tip-up use in Opaque Bowls.



FOR TIP-UP USE IN OPAQUE BOWLS

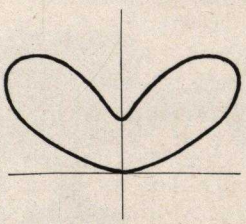
EC-15	100-200	$9\frac{1}{2}$"	$4\frac{1}{16}$"	$1\frac{13}{16}$"	MAZDA "C"
EC-344	300-400-500	12"	$5\frac{1}{16}$"	$1\frac{7}{8}$"	" "
EC-754	750-1000	16"	$6\frac{13}{16}$"	$2\frac{3}{8}$"	" "
E-40	40-50-60	$6\frac{1}{2}$"	$2\frac{9}{16}$"	1"	MAZDA "B"
E-15	25 W-G-18$\frac{1}{2}$	$4\frac{1}{4}$"	$1\frac{13}{16}$"	$\frac{9}{16}$"	" "

For lamps burning in horizontal position.



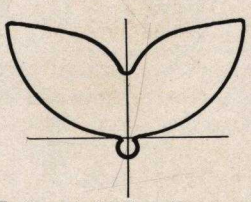
FOR HORIZONTAL BURNING IN OPAQUE AND LUMINOUS BOWLS

EC-71	75-100-150	$6\frac{1}{8}$"	5"	$3\frac{1}{8}$"	MAZDA "C".
E-60	40-50-60(75"C")	$5\frac{1}{16}$"	5"	3"	MAZDA "B" & "C".
E-155	200	$7\frac{7}{8}$"	$7\frac{7}{8}$"	$3\frac{7}{8}$"	MAZDA "C".



Typical light distribution curve of an opaque X-Ray indirect lighting reflector.

Any of the above reflectors may be used singly or in multiple in indirect lighting fixtures. For the larger lamp sizes the general practice is to use one lamp only, usually in a pendant dip-down position. Multiple unit interior equipment is shown on the next page



Typical light distribution curve of X-Ray indirect lighting reflector with opal glass diffuser.

X-RAY REFLECTORS FOR INDIRECT LIGHTING

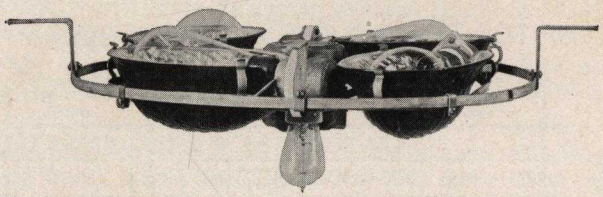


Fig. 20. A four light equipment for a luminous bowl fixture. Lamps burning horizontally.

The above is a complete equipment ready to be placed into the reflector bowl. The ring band with its angular projection serves to support the interior in the bowl. This style of equipment is especially suitable for shallow reflector bowls.

Fig. 21. The interior shown above installed in a fixture.

The lamps are in opaque reflectors and direct the light to the ceiling. The lighting of the glass bowl of the fixture is accomplished by means of a small lamp which projects from the socket at the bottom of the center body of the equipment. The brightness of the bowl can be regulated by the size of the lamp.

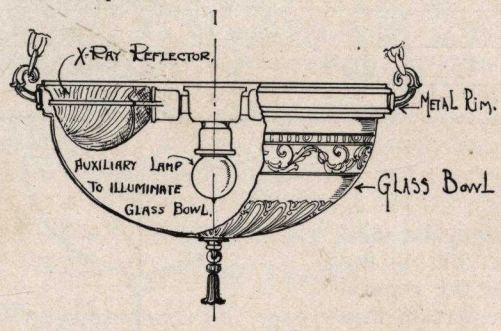


Fig. 22. Sectional view of luminous bowl fixture.

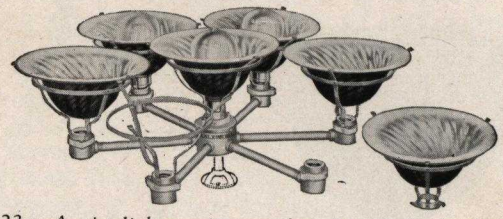


Fig. 23. A six light equipment for an opaque bowl fixture Lamps burning vertically tip-up.

In many interiors it is preferable to employ opaque bowl fixtures and often desirable to have the multiple unit arrangement so that the smaller sizes of lamps can be used, and also by placing lamps on separate circuits several intensities of light can be obtained from the same fixture. This latter condition is often found desirable for churches, theatres and auditoriums.

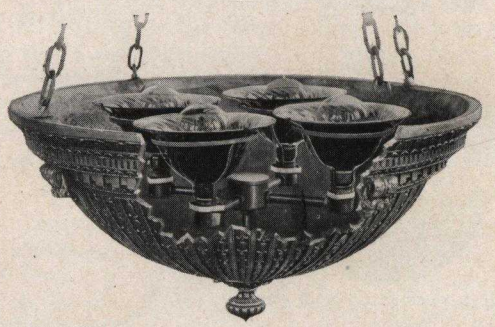


Fig. 24. Sectional view of an opaque bowl fixture.

The tip-up multiple unit equipment is most suitable for deep fixture bowls. It can be arranged for luminous bowl types as well as for the opaque as shown by the illustration.

All Mazda "B" lamps can be burned in any position. Mazda "C" lamps up to and including the 200-watt size can be burned horizontally tip up or tip down.

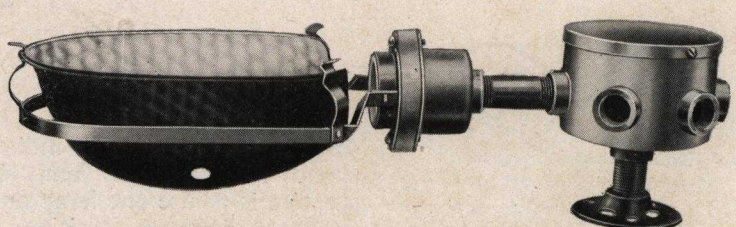


Fig. 25. Showing how the interior is made up with center body, receptacles, reflectors, and holders.

METHODS OF CALCULATION FOR X-RAY INDIRECT LIGHTING

The most convenient method now in common use for the making of lighting calculations is known as the flux of light method, or lumen method. The application of this method is dependent upon a full knowledge of the characteristics of the lighting equipment and its applications to the different types of interior.

Only a part of the light from an indirect lighting unit reaches the plane of reference. The same is true of any lighting system, as an inspection of the light distribution of any lamp or lamp and reflector combination will show. In all cases some light strikes the ceiling and walls, a portion of which is lost by absorption. Then, too, the reflector itself absorbs a portion of the available light flux.

THE LUMEN METHOD

The application of the lumen method of calculation assumes an intimate knowledge of the percentage of the total light flux available on the plane of reference under numerous conditions. This percentage, called the *efficiency of utilization*, is determined experimentally in the following manner: An installation of indirect lighting, for instance, is set up in a room of given proportions and color of ceiling and walls. The illumination delivered to the plane of reference is measured, and the average for all the area determined. Calibrated lamps of known lumen output are used, and in this way the efficiency of utilization, or percentage of the original light of the lamp falling upon the area, is determined for this particular room.

In the same way a great many different installations are measured, supplying data from which a table of utilization of efficiency may be constructed. The Table No. 1 is a result of many such tests, and is broad enough in scope to cover most ordinary installations of indirect lighting. Similar tables for direct lighting are available.

Color of Ceilings

In designing X-Ray indirect lighting, it must be borne in mind that the ceiling of the room to be illuminated becomes the secondary source of light, hence the ceiling should be an efficient reflector in order that it will reflect and diffuse the maximum quantity of light. Ceilings finished in a matte white, very light cream or very light ivory are recommended. It has been found that a color for the ceiling similar to that of the ordinary United States penny postcard is most satisfactory. A glossy finish on the ceiling is as satisfactory as a matte finish from a standpoint of reflecting efficiency, and usually as regards diffusion, but falls short in appearance and in ocular comfort. A blurred image of the lamp and reflector on the glossy surface produces a decided glare. It is best, therefore, to avoid the use of glossy finishes on ceilings when they are used as reflecting surfaces for indirect lighting. In working out Table No. 1, it has been assumed that the coefficient of reflection of the ceiling is about 65 per cent.

TABLE NO. 1

Dimension Factor*	Efficiency of Utilization—Per Cent†		
	Light Walls Co-efficient of Reflection .65	Medium Walls Co-efficient of Reflection .40	Dark Walls Co-efficient Reflection .35
1	.27	.17	.14
2	.34	.26	.22
3	.38	.31	.26
4	.40	.34	.30

*Dimension factor—$\frac{\text{Minimum dimension of room}}{\text{ceiling height}}$

†These values of utilization efficiency apply only for installations in interiors having white or light cream ceilings (co-efficient of reflection about .65).

From Table No. 1 it will be noted that the efficiency of utilization varies with the proportions of the room. Thus, in a narrow, high room the efficiency is lower than in a broad, low room. The chief reason for this is the greater loss of light in double reflection from the walls. Referring to figure 19, it is apparent that if the side walls are moved in close to the fixtures, the condition of a high, narrow room, a greater number of the reflected rays from the ceiling will be intercepted by the wall, similar to A2, whereas, if the walls are moved away from the fixtures, the condition of a broad, low room, more reflected rays will reach the plane of reference directly like A1. Hence in the latter instance the efficiency of utilization will be higher than in the former. The color of the walls also have an effect on the efficiency of utilization. If the walls are dark, but little light intercepted by them will be available on a plane of reference. But if they are light, a considerable increase in efficiency results.

Having knowledge of the utilization efficiency that may be expected under various conditions of every-day lighting practice, the next step is to determine the quantity of luminous flux or number of lumens it is necessary to deliver to the plane of reference in order that the lighting may be satisfactory. This quantity depends upon a number of factors: (1) dark colored objects require more illumination than light ones; (2) work requiring close discrimination of line detail requires higher illumination intensity than, for instance, ordinary reading; (3) for long periods of application, high intensities are helpful in reducing eye fatigue;

TABLE NO. 2

Illumination in Foot Candles and Wattage per Square Foot for Various Requirements

Kind of Interior	Foot Candles	Watts per Sq. Ft.
Armories — Assembly Hall	3	.80
Company Rooms	3	.80
Office	4	1.05
Art Galleries — Exhibition Rooms	4	1.05
Painting Galleries (Room)	3	.80
(Walls)	5	1.30
Assembly Halls	3½	.90
Auditoriums	3½	.90
Banks—Account Room	5	1.30
Banking Space	5	1.30
Consultation Room.	3	.80
General Office Space	5	1.30
Public Space	3	.80
Private Offices	4	1.05
Stenographic Room.	6	1.60
Vaults and Filing	2½	.65
Barber Shops	5	1.30
Churches--Auditoriums	3	.80
Choir Room	2½	.65
Foyer	2½	.65
Pastor's Study	3	.80
Sunday School Room	3	.80
Vestibule	2	.55
Court Room	3½	.90
Clubs—Ball Room	3½	.90
Barber Shop	4½	1.20
Card Room	3½	.90
Corridors	1½	.40
Dining Room	3½	.90
Lobby	4	1.05
Lodge Room	3½	.90
Lounging Room	2½	.65
Drafting Rooms	10	2.60
Display Rooms—Dark Displays	6	1.60
Light Displays	5	1.30
Factories — Drafting Room	10	2.60
Offices	5	1.30
Sewing Rooms	8	2.00
Work Room Spaces.	5	1.30
Gymnasium	3½	.90
Hospitals—Corridors	1	.25
Operating Room	10	2.60
Preparation Rooms.	4	1.05
Wards—Dim Illumination	½	.15
Bright Illumination	1½	.40
Medium Illumination	3	.80
Hotels—Ball Room	3½	.90
Barber Shop	4½	1.20
Bath Room	2	.55
Bed Room	2	.55
Billiard Room	5	1.30
Buffet	4	1.05
Card Room	3½	.90
Corridor	1½	.40
Dining Room	3½	.90
Kitchen	4	1.05
Lobby	4	1.05
Lounging Room, or Rest Room	2½	.65
Parlor	2	.55
Restaurant	3½	.90
Writing Room	3½	.90
Libraries—Book Stacks	2½	.65
Corridor	1½	.40
Catalog Room	3½	.90
Delivery Room	3½	.90
Lecture Room	3	.80
Lobby	2½	.65
Reading Room	4½	1.20
Lodge Rooms	3½	.90
Offices and Office Buildings—Accounting.	5	1.30
Consultation Room.	3	.80
Corridors—1st floor.	2	.55
Under corridors, above 1st floor	1½	.40
Drafting	10	2.60
General Office	5	1.30
Lobby	4	1.05
Private Offices	4	1.05
Reception Room	3	.80
Stenographic	6	1.60
Stock Room	2½	.65
Vaults and Filing	2½	.65
Railway Stations—Ladies Retiring Room	3	.80
Main Waiting Room	4½	1.20
Smoking Room	3	.80
Ticket Office	4	1.05
Residences—Bed Room	2	.55
Billiard Room	6	1.60
Bath Room	1½	.40
Den	4	1.05
Dining Room	3 max.	.80
Dressing Room	2	.55
Hall	1½	.40
Kitchen	4	1.05
Living Room	4 max.	1.05
Library	4	1.05
Music Room	2½	.65
Play Room	2	.55
Porch	1½	.40
Sewing Room	6	1.60
Sun Room	4 max.	1.05
Restaurants	3½	.90
Schools--Assembly Hall	3½	.90
Class Rooms, Study Rooms	4	1.05
Class Rooms in Business College	4½	1.20
Library and Reading-Room	4½	1.20
Museum	3	.80
Sewing Room (large)	8	2.00
Shops (millinery, haberdashery, candy, cigars, etc.)	5	1.30
Skating Rink	2	.55
Stores—Fitting Room.	5	1.30
Large Store — Sales Space, 1st floor	8	2.00
Upper	5	1.30
Small Store	5	1.30
Studios	4	1.05
Swimming Pools	3½	.90
Telephone Exchanges—Offices	4	1.05
Operating Room	4	1.05
Rest Rooms	3	.80
Theatre — Auditorium	3½	.90
Auditorium — Motion Picture Theatre, dim illumination while pictures are shown	½	.15
Bright illumination during intermission	3½	.90
Box Office	4	1.05
Foyer	5	1 30
Ladies' Retiring Room	3	.80
Lobby	4	1.05
Smoking Room	3	.80

(4) for rapid seeing, high intensities are essential; (5) for general observation, moderate intensities are adequate. From long experience, we have come into possession of quite definite knowledge of the illumination intensity required for a variety of purposes.

In Table No. 2 is tabulated the intensity in foot candles commonly recognized as satisfactory lighting in a number of types of interiors in which indirect lighting proves ideal. Since the foot candle is the flux density in lumens per square foot; multiplying the area to be illuminated by the required foot candle intensity gives the effective lumens which must be delivered to the area.

To illustrate the method of procedure in making calculations by the lumen method, the following example is given:

Example

Suppose we are required to illuminate an office 30 by 25 feet in area, ceiling 11 feet high, walls light, and ceiling white. The character of the work is clerical, requiring long application but no observation of fine details.

Solution

From Table No. 1, the efficiency of utilization we may expect to secure is found to be about .34. The intensity of illumination required from Table No. 2 is 5-foot candles. Area to be illuminated is 750 square feet. Effective lumens which must be delivered to plane of reference, 750 x 5, equal

LUMEN DATA FOR MAZDA LAMPS.

VOLTAGE CLASS : 110 TO 125 VOLT.

RATED WATTS.	DIAMETER OF BULB INCHES	OVERALL LENGTH INCHES.	LIGHT CENTER LENGTH INCHES.	BASE	LUMENS PER WATT	LUMENS. TOTAL	25%	30%	35%	POSITION OF BURNING.
				MAZDA "B" LAMPS.						
10	2 1/8"	4 7/8"	2 1/8"	MED. SCR.	7.52	75	19	22	26	ANY
15	2 1/8"	4 7/8"	"	" "	8.32	125	31	37	44	"
25	2 3/8"	5 1/4"	3 1/4"	" "	8.91	223	56	67	78	"
40	2 3/8"	5 1/4"	"	" "	9.24	369	92	111	129	"
50	2 3/8"	5 1/2"	"	" "	9.45	473	118	142	165	"
60	2 5/8"	5 1/2"	3 7/16"	" "	9.59	575	144	172	205	"
100	3 1/4"	7 1/8"	5 5/16"	" "	9.97	997	249	300	349	"
				MAZDA "C" LAMPS.						
75	2 3/4"	6 1/8"	4 5/16"	MED. SCR.	11.53	865	216	259	303	ANY
100	3 1/8"	7 1/8"	5 5/16"	" "	12.57	1257	314	377	439	"
150	3 1/8"	7 1/8"	5 5/16"	" "	13.66	2049	513	615	717	"
200	3 3/4"	8 3/8"	6"	" "	14.61	2922	730	877	1024	TIP DOWN
300	4 3/8"	9 3/4"	7"	MOG. SCR.	16.11	4833	1208	1450	1700	" "
400	5"	10"	7"	" "	16.76	6704	1675	2015	2345	" "
500	5"	10"	7"	" "	17.45	8727	2185	2617	3050	" "
750	6 1/2"	13 3/8"	9 1/2"	" "	18.48	13860	3465	4158	4840	" "
1000	6 1/2"	13 3/8"	9 1/2"	" "	19.33	19330	4830	5800	6775	" "

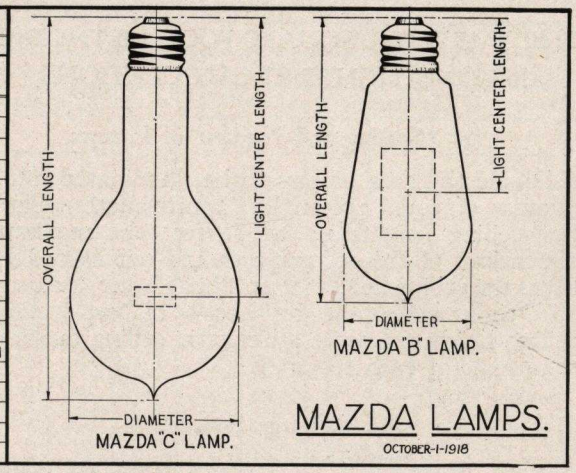


Fig. 26. Dimensions and lumen data for Mazda "B" and Mazda "C" Lamps.

3,750 lumens; total lumens lighting units must supply 3,750 ÷ .34, equal to 11,029 lumens.

Hence the lighting units to be installed must have a combined luminous output of approximately 11,000 lumens in order to provide an intensity of 5-foot candles on the plane of reference.

In Fig. 26 the lumen output of incandescent lamps of American make are listed.

From this table it will be noted that either 4 200-watt lamps or 1 750-watt lamp will deliver the required number of lumens.

The choice of the number of units is dependent upon the dimensions of the interior and the character of the work carried on. In the present example uniform illumination is desirable, but in many instances a degree of non-uniformity is permissible.

With indirect lighting the spacing between outlets should not exceed 1½ times the ceiling height, if the illumination on the horizontal plane 30 inches above the floor, desk level, shall be uniform. Where uniformity of intensity is not essential, greater spacings are permissible, but in extreme cases should not exceed 2½ times the ceiling height. Hence for the above example, four lighting units should be employed located at the center of each quarter of the room. This means that we must employ 4 200-watt units in order to secure the uniform intensity of 5-foot candles on the plane of the desk.

Refer to Fig. 27 for information regarding the length of suspension of the indirect lighting fixture. This chart shows the ceiling spread for various hanging heights. The length

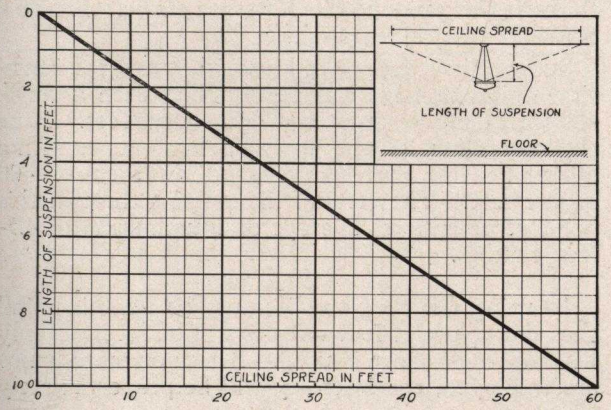


Fig. 27. Chart for determining spacing and hanging distances for indirect lighting fixtures.

of the suspension should be chosen so that the illuminated areas on the ceiling from adjoining units overlap since this gives the most pleasing ceiling effect. With the properly designed X-ray reflectors for indirect lighting, this may be accomplished with the ordinary suspension and without great loss in efficiency of reflection from the ceiling.

LAMP DATA

The information given in the table of Figure 26 includes the principle Mazda "B" and Mazda "C" lamp, those most frequently used for standard lighting service. Only those lamps of the 110-125 voltage class are included. The data covering the dimensions of the bulbs, the values of total lumens, and size of base were taken from catalogs of lamp manufacturers.

The values of lumens under the headings 25, 30, and 35 per cent are the number of lumens effective or usable at corresponding efficiencies of utilization.

Lamps designated for burning in any position can be employed horizontally, tip up, tip down, or at an angle. Those designated for tip down burning should normally be burned in that position only. Mazda "C" lamps of 200 watts and above can be obtained on special order for tip up burning.

SUSPENSION CHART

The chart in Figure 27 shows for various suspension heights the maximum size of circular ceiling area which can be uniformly illuminated from a single lighting unit.

For instance it is seen from the chart that for an area 18x18 feet to cover the ceiling uniformly units should be suspended about 36 inches from the ceiling.

In determining the suspension height for indirect lighting fixtures other conditions should be taken into consideration, as for instance the appearance of the unit when hanging in place, the general dimensions of the room and the relation of the fixture to other fixtures in the area and adjoining spaces.

THE WATT PER SQUARE FOOT METHOD OF MAKING LIGHTING CALCULATIONS

(1) Spacing and Number of Fixtures

Divide the area or bay to be illuminated into a number of equal rectangles, approximate squares. For ceiling heights up to 12 feet the maximum dimensions of the rectangle should not exceed 1½ times the ceiling height; from 12 to 17 feet, inclusive, 1.75 times ceiling height, above 18 feet 2 times ceiling height. Locate an electric ceiling outlet at the center of each rectangle.

(2) Wattage Required

Select from Table No. 2 the wattage per square foot required for the particular interior, multiply the area of one rectangle obtained from No. 1 above by this quantity and obtain the required wattage per outlet or fixture.

(3) Number of Lamps Per Fixture

Knowing the watts per fixture and the wattage of the lamp it is desired to use, the number of lamps per fixture may be readily obtained.

(4) Type of Reflector and Length of Suspension

The data on page 31 gives the proper type of reflector for the various lamp sizes. From the diagram in Figure 27 the correct length of suspension can be determined for the size of rectangle or area that is to be lighted from one reflector.

Example

It is required to illuminate a general office having the following dimensions per square or bay. Length 17 feet, width 12 feet 4 inches, ceiling height 14 feet 6 inches.

(1) Spacing of Number of Fixtures

Multiply the ceiling height 14 feet 6 inches by 1.75 to obtain 25.4 feet the maximum dimension of the rectangle that can be illuminated from one center outlet. Since the length of the bay does not exceed 25.4 feet one fixture per bay will be satisfactory. Therefore, the dimensions of the rectangle to be illuminated from one center outlet are 17 feet by 12 feet 4 inches.

(2) Wattage Required

For a general office 1.3 watts per square foot (see Table No. 2) should be used. Multiply the area of one rectangle 17 feet by 12 feet 4 inches or 210 square feet by 1.3 and obtain 273 watts.

(3) Number of Lamps Per Fixture

Suppose it is desired to use single unit fixtures. A 300-watt lamp obviously is the nearest size of lamp which will be satisfactory.

(4) Type of Reflector and Length of Suspension

Referring to page 31, the reflector called for in this case is the EC-345 and by referring to Fig. 27 the suspension height is determined to be 36 inches from the upper edge of the bowl to the ceiling.

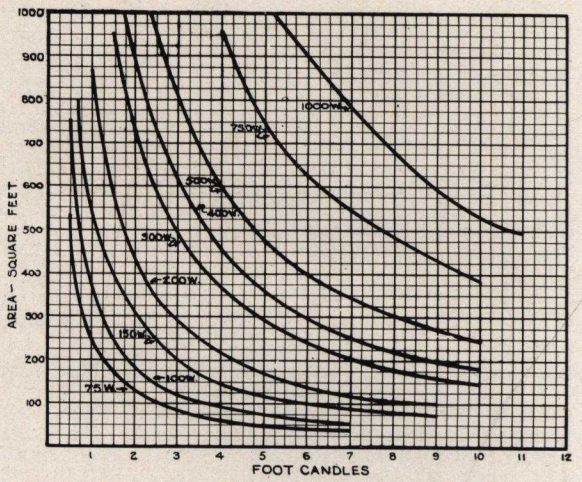


Fig. 28. Diagram for the rapid calculation of lighting intensity for a single lamp and for a given area.

SHORT CUT METHODS OF CALCULATION

Fig. 28 consists of a diagram for rapid illumination computations corresponding to an efficiency of utilization of 30%. Curves are given for the various sizes of lamps and show the relation existing between the average horizontal illumination on the working plane in foot candles and the area of the room or bay.

As an example, suppose it is desired to illuminate a bay 20 by 20 feet with an average of intensity of illumination of 6-foot candles.

Referring to the left hand scale of the chart, locate the intersection of the horizontal lines corresponding to an area of 400 square feet with the vertical line corresponding to an illumination intensity of 6-foot candles. The nearest curve passing through this point is the 500-watt curve. Hence a 500-watt lamp is required.

Suppose it is desired to know what average intensity of illumination can be obtained with a single 400-watt lamp for an area of 400 square feet. Note the intersection of the 400-watt lamp curve with a horizontal line corresponding to an area of 400 square feet. The vertical line passing through this point represents an average of illumination of 4.5-foot candles.

In using the diagram, it must be kept in mind that the values of foot candles will be received only when a single lamp is used. If two or more lamps are employed, the intensity will be proportionately increased.

FOR MAZDA "C" LAMPS.

Foot Candles	75W. LAMP.		100W. LAMP		150W. LAMP.		200W. LAMP		300W. LAMP		400W. LAMP		500W. LAMP.		750W. LAMP.		1000W. LAMP.	
	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing
.5	.15	23'-0"	.13	27'-6"	.12	35'-0"	.11	42'-0"										
1.0	.29	16'-0"	.26	19'-6"	.24	24'-6"	.23	29'-6"	.21	38'-0"	.20	45'-0"						
1.5	.43	13'-0"	.40	16'-0"	.37	20'-0"	.34	24'-0"	.31	31'-0"	.29	36'-6"	.28	41'-6"				
2.0	.58	11'-6"	.53	13'-6"	.49	17'-6"	.46	21'-0"	.41	27'-0"	.40	31'-6"	.38	36'-6"	.36	46'-0"		
2.5	.72	10'-0"	.66	12'-6"	.61	15'-6"	.57	18'-6"	.52	24'-0"	.50	28'-6"	.48	32'-0"	.45	40'-6"		
3.0	.87	9'-6"	.80	11'-0"	.73	14'-6"	.68	17'-0"	.62	22'-0"	.59	26'-0"	.57	29'-6"	.54	37'-0"	.52	44'-0"
3.5	1.01	8'-6"	.93	10'-6"	.86	13'-0"	.72	16'-6"	.72	20'-6"	.70	24'-0"	.67	27'-6"	.63	35'-0"	.60	41'-0"
4.0	1.16	8'-0"	1.06	9'-6"	.97	12'-6"	.92	14'-6"	.83	19'-0"	.79	22'-6"	.77	25'-6"	.73	32'-6"	.69	38'-0"
4.5	1.31	7'-6"	1.19	9'-0"	1.10	11'-6"	1.04	14'-0"	.93	18'-0"	.90	21'-0"	.86	24'-0"	.81	30'-0"	.77	36'-0"
5.0	1.44	7'-0"	1.32	8'-6"	1.22	11'-0"	1.14	13'-0"	1.04	17'-0"	.98	20'-0"	.96	23'-0"	.91	28'-6"	.87	33'-6"
6.0	1.74	6'-6"	1.59	8'-0"	1.46	10'-0"	1.37	12'-0"	1.24	15'-6"	1.18	18'-6"	1.14	21'-0"	1.09	26'-0"	1.03	31'-0"
7.0	2.02	6'-0"	1.85	7'-6"	1.71	9'-6"	1.60	11'-0"	1.44	14'-6"	1.40	16'-6"	1.33	19'-6"	1.26	24'-6"	1.21	28'-6"
8.0			2.11	7'-0"	1.95	9'-0"	1.83	10'-6"	1.65	13'-6"	1.57	15'-6"	1.52	18'-0"	1.44	23'-0"	1.37	27'-0"
9.0					2.20	8'-6"	2.05	10'-0"	1.86	12'-6"	1.78	15'-0"	1.72	17'-0"	1.62	21'-6"	1.55	25'-6"
10.0									2.06	12'-0"	1.98	14'-0"	1.90	16'-0"	1.80	20'-0"	1.73	24'-0"
11.0																	1.90	23'-0"
12.0																October 1, 1918		

Fig. 29. Chart for quick determination of lighting intensity, spacing of units, proper lamp size and watts per square foot required.

ILLUMINATION CHARTS

For the various standard lamp sizes the tables in Figures 29 and 30 give the average foot candle intensities obtainable on the working plane at various spacings. The wattage consumption in watts per square foot is also shown.

All of the values in these tables are based upon an efficiency of utilization of 30 per cent.

These charts should be used in connection with the chart given in Figure 27 which shows the size of circular ceiling area that can be uniformly illuminated from a single unit from various suspension heights.

The working of these charts is best illustrated by a few examples.

FOR MAZDA "B" LAMPS.

Foot Candles	25W. LAMP.		40W. LAMP.		50W. LAMP.		60W. LAMP.		100W. LAMP.	
	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing
.25	.093	16'-6"	.091	21'-0"	.088	24'-0"	.087	26'-6"	.084	35'-0"
.50	.19	11'-6"	.18	15'-0"	.17	17'-0"	.17	19'-0"	.16	25'-0"
.75	.28	9'-6"	.27	12'-6"	.26	14'-0"	.26	15'-6"	.25	20'-0"
1.00	.37	8'-6"	.36	10'-6"	.35	12'-0"	.34	13'-0"	.33	17'-6"
1.50	.56	7'-0"	.54	8'-6"	.53	10'-0"	.52	11'-0"	.50	14'-0"
2.00	.75	6'-0"	.72	7'-6"	.70	8'-6"	.69	9'-6"	.67	12'-6"
2.50	.93	5'-6"	.90	6'-6"	.88	7'-6"	.87	8'-6"	.83	11'-0"
3.00	1.12	5'-0"	1.09	6'-0"	1.06	7'-0"	1.05	7'-6"	1.00	10'-0"
3.50	1.31	4'-6"	1.26	5'-6"	1.23	6'-6"	1.22	7'-0"	1.17	9'-6"
								October 1, 1918		

Fig. 30. This chart for Mazda "B" Lamps serves the same purpose as Fig. 29 for Mazda "C" Lamps.

Example

Assuming an office space of 40x90 feet to be illuminated to an average intensity of 5 foot candles what size of lamp will be required?

The area is divided by columns into 10 equal spaces or bays 18x20 feet. We can take this smaller area as a basis for calculations.

Find the 5 foot candle value in the column at the left of the chart. Now, in the horizontal line opposite 5 foot candles the values are given for the spacing and watts per square foot for each lamp size. Let us assume that only one lamp is to be used for each 18x20 foot space. The spacing that most nearly corresponds with the size of the area is given as 20 feet under the 400 watt lamp. The 400 watt lamp is, therefore, the size to be used to give the illumination desired.

Example

Given an area 22x44 feet lighted by 8 units consisting of indirect lighting fixtures each containing a 200 watt Mazda "C" lamp. What illumination foot candles will be received?

If the units are spaced symmetrically, say 11 feet apart, this spacing value indicates that 7 foot candles will be received. If the spacing is not known determine the watts per square foot by dividing the total wattage, 1,600 watts, by the area, 968 square feet, which in this case equals 1.65 watts per square foot. The value in the 200 watt column most nearly equal to 1.65 lies in a horizontal line opposite 7 foot candles. Hence, this is the average illumination intensity that will be received in the area.

Example

How many watts per square foot will be required to produce 4½ foot candles in a given interior using a 750 watt Mazda "C" lamp?

This can be read directly from the chart at the intersection at the horizontal line opposite 4½ foot and the vertical line below 750 watt lamp. We find that .81 watts per square foot is the required wattage consumption to give the foot candles desired.

Fig. 31. General Office of the VanDusen-Harrington Company, Minneapolis, Minn.

V APPLICATIONS OF INDIRECT LIGHTING

OFFICES, BANKS, STORES, CLUBS, HOSPITALS, ETC.

Fig. 32. Private office of F. W. Upham, President Consumers Company, Chicago, Illinois. Before and after X-Ray Lighting was installed.

OFFICES

LARGE employers of labor realize that human efficiency is quite as important as machine efficiency and that an equipment which tends to add to the convenience and comfort of the employees, their good will, and, most important of all, preserve their health and strength, is a paying investment.

For these reasons, such companies as the Curtis Publishing Company and Armour and Company when considering the lighting system for their new office buildings retained the services of special investigators, who for many months made a careful study of the lighting question. A very exhaustive method of investigation of all systems of modern illumination was made in which the original cost, cost of operation, cost of maintenance and depreciation were weighed against the seeing efficiency or visual acuity of the eye. As a result, X-Ray Indirect Lighting was selected and installed in these offices, as it has been in many others.

The Curtis Publishing Company of Philadelphia considered every known method of lighting. Tests were run for sixteen months in an office in which 200 employees worked. It is significant that 200 cast an unanimous vote in favor of the X-Ray Indirect Lighting System, and the test resulted in the equipping of this entire building with over 1,000 fixtures.

Armour and Company of Chicago investigated the lighting question for five months prior to installing over 900 fixtures throughout their office building. Their test shows that the maintenance cost for the Indirect Lighting to be more economical than for any other.

The X-Ray Indirect Lighting System is especially characterized by the following:

The absence of glare and eye strain

The increase of efficiency of those working under artificial light

The preservation of the health and the retention of the services of valuable employees

Uniform illumination of every square foot of available floor space, making desk arrangements independent of the lighting system

A more spacious and cheerful appearance of any room

Elimination of desk lamps

The absence of dark, dirty looking corners

Whenever natural business scope necessitates a re-arrangement of the office furniture, Indirect Lighting demonstrates one phase of its perfect fitness for the illumination of the office in allowing an arrangement of desks and files for greatest working efficiency, with the assurance that the illumination will be ample and uniform, no matter how or where they are placed, and all without the annoyance and expense of re-wiring or shifting of direct lights.

The system makes every square foot of floor space

Fig. 33. General office Illinois Steel Company in Continental & Commercial National Bank Bldg., Chicago, Ill. Graham Burnham Co., Architects.

Fig. 34. General office of Armour & Company, Chicago, Ill. R. C. Clark, Architect.

for which rent or taxes are paid available for business purposes, by uniformly lighting the entire room with an illumination so diffuse and uniform in character as to eliminate sharp interfering shadows cast by the furniture or the body of the worker. These shadows are always found where the lighting is from visible, exposed sources.

In short, the Indirect Lighting System makes the lighting entirely independent and permits the most efficient use of the entire room at all times.

Antiquated desk or drop lights and the various visible light sources present with direct or so-called semi-indirect lighting installations are responsible for many of the headaches which incapacitate office employees for efficient and accurate work. With desk units bright light is reflected directly into the eyes of the worker causing the worst form of eye strain. The localized lighting must always be supplemented by a general lighting.

Comparison of an indirect lighting installation scientifically made, giving the proper intensity of light for offices and uniform distribution, should not be made with direct lighting installations which are, in the majority of instances, unsatisfactory in many ways. A fair comparison of any two systems of lighting for the same interior should be on the following basis:

Ability to sustain clear seeing under the artificial lighting

Psychological and physiological effects on the employees

General effect from a welfare and humanitarian standpoint

Current consumption

Cost of maintenance or upkeep

First cost of wiring

Fixture cost

Architectural and aesthetic advantages

When all of the above are properly considered, one must conclude that current consumption should not and does not, these days, decide the question as to which is the most efficient system for office use.

Until recently the question of cost was usually decided on current consumption instead of greatest human efficiency.

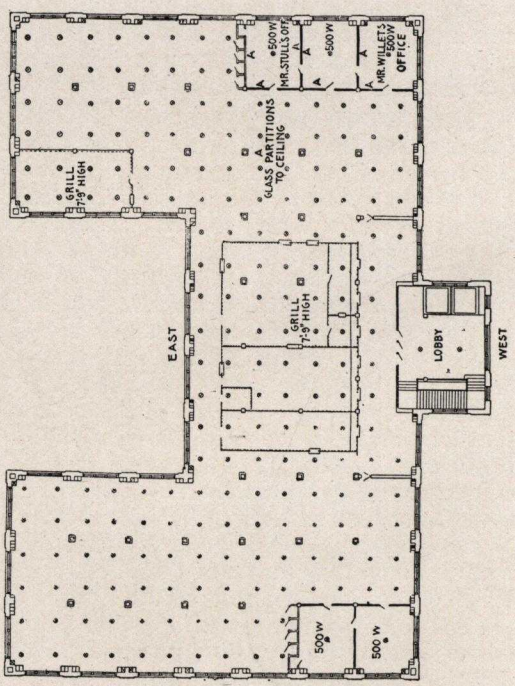


Fig. 35. Typical floor plan of Armour & Company office building.

Fig. 36. Effect of X-Ray indirect illumination in post office, Malmo, Sweden.

The illustration of the Order Department of the Illinois Steel Company shows only one of the many general offices in the Continental and Commercial Bank building of Chicago which are lighted

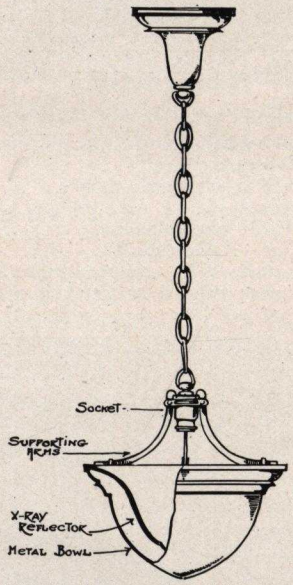


Fig. 37. Office lighting fixture adopted by Armour & Company.

ARMOUR COMPANY, CHICAGO, ILL.

Main Office

GENERAL NOTES:

Size of typical bays—17 x 21 feet.
Floor area—357 square feet.
Height of ceiling—15 feet 9 inches.
Number of fixtures—per bay, 4.
Lamps per fixture—One 100-watt.
Type of reflector—X-Ray No. EC-12.
Wattage consumed—1.1 watts per square foot.
Fixtures suspended—24 inches.
Fixtures spaced—8 to 10 feet apart.

ILLINOIS STEEL COMPANY, CHICAGO, ILL.

General Office

GENERAL NOTES:

Size of typical bay—20 x 20 feet.
Floor area—400 square feet.
Height of ceiling—13 feet.
Number of fixtures—1.
Lamps per fixture—4-150.
Type of reflector—X-Ray No. E-61.
Wattage consumed—1.5 watts per square foot.
Fixtures suspended—30 inches from ceiling.
Fixtures spaced—20 feet apart.

throughout with X-Ray Indirect Lighting. The magnificent bank building is the largest office building in Chicago. The bank itself occupies the first seven floors of the building, and all except the first floor are lighted with Indirect Lighting.

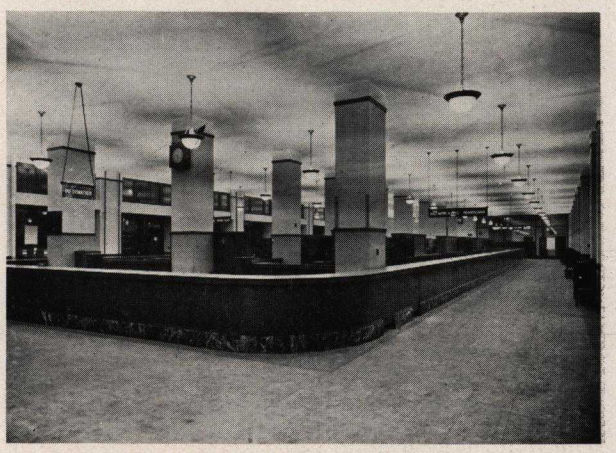


Fig. 38. U. S. Railroad Administration, Consolidated Ticket Office, Chicago, Ill. Insurance Exchange Bldg., Graham Burnham Co., Architects

The Luminous Bowl Fixture for Office Lighting

The managers of many offices prefer to install the luminous bowl fixture, because of its cheerful effect and the suggestion it gives of the source of light. A fixture of this kind is just as efficient as far as the illumination of the room is concerned as the opaque X-Ray Indirect Lighting fixture. Both contain reflectors which throw the maximum of the light to the ceiling, where it is re-directed down into the room. The lighting of the bowl is entirely independent of the lighting of the room, and is accomplished by means which are described on previous pages. With this fixture the effect of the lighted bowl is obtained without the glare that results from the semi-indirect lighting method. The fixture bowl should not be the brightest object in the room, because the eye adjusts itself to the brightest spot in the range of vision. Seeing ability would, therefore, be decreased with such an arrangement.

Fig. 39. Private office Minneapolis General Electric Company, Minneapolis, Minn.

Private Offices

The average private office can be taken care of, as far as the lighting is concerned, with one fixture. Some of the larger private offices require two or even four. The central unit, however, is in most cases satisfactory, and can be either the opaque type as shown in Figure 42, or the luminous style of fixture as illustrated in Figure 39. The intensity requirement for the illumination is not quite as high as for general offices where more careful work is carried on, such as typewriting, book-keeping, etc. The desk and table lamp can be eliminated where the indirect lighting system is installed.

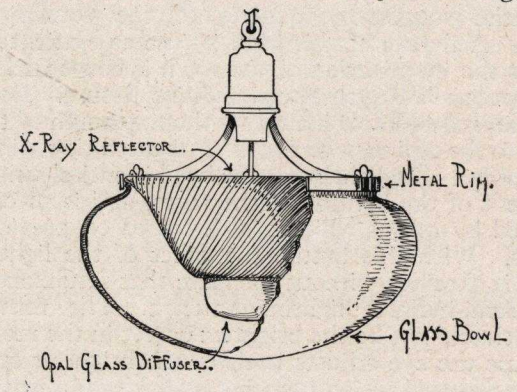


Fig. 40. Cross sectional view of fixture used in Minneapolis private office.

Fig. 41. Private Office—J. A. Jakobsson, Malmo, Sweden

Y. M. C. A., BELOIT, WISCONSIN

Secretary's Office

GENERAL NOTES:

Size of room—13 x 16 feet.
Floor area—208 square feet.
Height from ceiling—10 feet 6 inches.
Number of fixtures—1.
Lamps per fixture—one 200-watt.
Type of reflector—X-Ray EC 12.
Wattage consumed—.92 watts per square foot.
Fixture suspended—30 inches from ceiling.

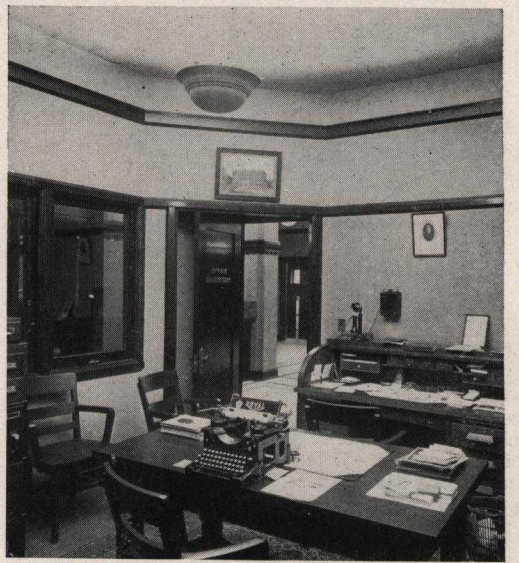


Fig. 42. Office of General Secretary, Y. M. C. A., Beloit, Wis. Shattuck & Hussey, Architects, Chicago, Ill.

Fig. 43. Daylight view from staircase landing—Offices for the Crown Agents for the Colonies, Westminster, London.

Fig. 44. Daylight view Crown Agents' Room No. 2.

Offices for the Crown Agent for the Colonies London

A fine building to accommodate the Crown Agents for the Colonies is situated in Millbank, Westminster, London. This building is the work of Architects, John W. Simpson, F.R.I.B.A. and Flight-Lieut. Maxwell Ayrton, R.M., A.R.I.B.A. The idea of the architects was to avoid, as far as possible, that conventional type of design, which, within recent years, has hovered dangerously on the verge of the stereotype for Government Buildings. They, therefore, abandoned all Government office traditions in designing this new building. The illustrations indicate that they have met with considerable success.

The most important feature of the interior of the building is the staircase, which runs the whole height of the building. The most interesting rooms of the building are the offices of the Crown Agents, situated next to each other on the first floor. The refined decorative scheme is shown in the illustration. Fig. 44. The wall panels are colored a delicate creamy gray, lined around with a color of a somewhat darker tone.

The indirect lighting fixtures for the building were supplied by the British Thompson-Houston Company of London and consist mostly of standard "Eye-Rest" type, as the X-Ray Indirect Lighting System is known in England. The fixtures used in the private offices, also the large fixture at the top of the staircase, were especially made up from designs prepared by the company and approved by the architect.

Fig. 45. Night view—Typical office interior Crown Agents for the Colonies, Westminster, London.

Fig. 46. Public space, First National Bank, Los Angeles, Cal. Weary & Alford, Architects, Chicago, Ill.

Fig. 47. The Standard Trust Company, Chicago, Ill. Using the X-Ray Luminous Bowl Fixtures

BANKS

A recent nation-wide investigation into the problem of bank advertising and service indicated that the effective lighting of the bank building is one of the greatest factors in emphasizing the bank's individuality. The warmth of a cheerful banking room pleases the customers and shatters the delusion that the modern bank is merely a cold storage for money.

Attractive buildings are an important feature in developing new business. During the past ten years the construction of new bank buildings has progressed at a remarkable rate and among the outstanding features of these buildings are the lighting arrangements.

The entire architectural scheme of banking rooms is designed to impress the prospective client with the sterling solidity of the institution. In no way may confidence be inspired better than by imparting that atmosphere of refinement, of dignity, and of spaciousness to the interior which invariably accompanies a proper installation of *lighting from concealed sources.*

The artistic effects which are sought by expensive decorations, marble work, and grills are often ruined by the glare of light from exposed lamps. The eye, instead of being impressed by the handsome interior, softly illuminated, is instantaneously attracted by the harsh brightness of the light source itself.

The lighting installation must, of course, do more than simply bring out the architectural beauties of the interior. It must be a practical system; one which will provide illumination of the proper quality for the public space of the bank and also lighting of correct intensity for the working area.

There are many ways to secure the practical results. Banks may be lighted with ceiling fixtures as shown on this page, or from the tops of cages, coves, etc., as illustrated on page 92. Where local lighting is desired in the Tellers' cages to supplement the general illumination, equipment illustrated on page 225 is admirably adapted.

FIRST NATIONAL BANK, LOS ANGELES, CAL.

Public Space

GENERAL NOTES:

Size of room—56 x 100 feet.
Floor area—5600 square feet.
Height of ceiling—25 feet.
Number of fixtures—10.
Lamps per fixture—12-100 watt.
Type of reflector—X-Ray No. EC-15.
Wattage consumed—2.14 watts per square foot.
Fixtures suspended—72 inches from ceiling.
Fixtures spaced—16 to 28 feet apart.

Fig. 48. Banking room, London & Southwestern Bank ,London, England.

STORES

Fig. 49. Store, L. S. Ayres & Co., Indianapolis, Ind. Vonnegut, Bohn & Mueller, Architects.

The best evidence of importance of illumination is the way in which the latest and more modern stores have been lighted. There has been a distinct desire on the part of the merchant to obtain good lighting and at the same time contribute as much as possible to the physical comfort of the patrons and sales people. Typical examples of this are shown by the illustrations given on these pages of the department stores of L. S. Ayers & Company, Miller & Paine and Chas. A. Stevens & Bros.

The purchase of lighting equipment should be on the same basis as the purchase of showcases, display fixtures or elevators and the following points given careful consideration:

Advertising value
Comfort of patrons and sales people
Initial cost
Cost of maintenance and up-keep

The glare from blazing lamps detracts rather than adds to the attractiveness of the interior. The first impression upon the customer upon entering the store counts for much. Therefore, the importance of giving careful study to the illumination of the first floor especially, cannot be over-emphasized. A good lighting system properly applied can be made to pay dividends from the standpoint of advertising. The store owner, of course, is always interested in the profits of his business.

The Ceiling Effect

In planning the artificial illumination of a store, it is very desirable to suspend the indirect lighting fixtures in such a way that a uniform ceiling effect will be obtained—that is, without alternate light and dark areas on the ceiling. The even brightness depends upon the design of the reflector employed, and also upon the suspension of the unit. The proper distances at which the fixture bowl should be hung from the ceiling is given in Figure 27 on page 35.

Reference should be made to the additional examples of good store lighting given by the detailed plates on pages 87 and 96.

L. S. AYERS COMPANY, INDIANAPOLIS, IND.

Department Store—1st Floor

GENERAL NOTES:

Size of typical bays—20 x 21 feet.
Floor area—420 square feet.
Height of ceiling—18 feet.
Number of fixtures—1 per bay.
Lamps per fixture—1-500 watt.
Type of reflector—X-Ray No. EC-344.
Wattage consumed—1.2 watts per square foot.
Fixtures suspended—48 inches from ceiling.
Fixtures spaced—21 feet apart.

CHAS. A. STEVENS & BROS., CHICAGO, ILL.

Sales Room, 2nd Floor

GENERAL NOTES:

Size of typical bay—25 x 25 feet.
Floor area—625 square feet.
Height of ceiling—16 feet.
Number of fixtures—1.
Lamps per fixture—4-200 Watt.
Type of reflector—X-Ray No. EC-15.
Wattage consumed—1.28 watts per square foot.
Fixtures suspended—60 inches from ceiling.
Fixtures spaced—25 feet apart.

Fig. 50. Store, Charles A. Stevens & Brothers, Chicago, Ill. Graham Burnham Co., Architects.

Fig. 51. Store, Miller & Paine Dry Goods Co., Lincoln, Nebraska. Berlinghoff & Davis, Architects.

MILLER & PAINE CO., LINCOLN, NEBR.

First Floor Salesroom

GENERAL NOTES:

Size of typical bay—18 x 20 feet.
Floor area—360 square feet.
Height of ceiling—15 feet.
Number of fixtures—45.
Lamps per fixture—Six 100-watt.
Type of reflector—X-Ray EC-15.
Wattage consumed—1.67 watts per square foot.
Fixtures suspended—48 inches.
Fixtures spaced—18 and 20 feet apart.

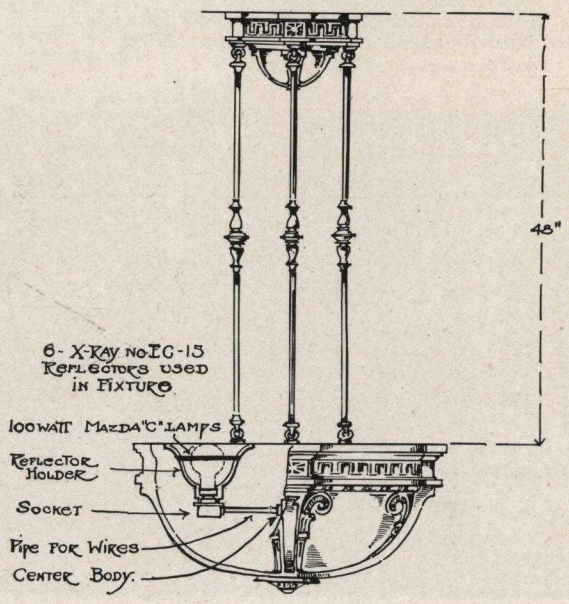


Fig. 52. Diagram of store fixture used by Miller & Paine, Lincoln, Nebraska.

Fig. 53. First floor—C. G. Gunthers Sons' Store, New York, N. Y.

Gunthers' Store

The store illustrated above is that of P. G. Gunthers, retailers of furs on Fifth Avenue, New York City. On the main ceiling of the first floor four special fixtures having stalactite bowls equipped with X-Ray luminous bowl reflectors are used. These give a high intensity of light on the mezzanine floor and on the main floor with the exception of the section under the mezzanine. To build up the light in this area X-Ray reflectors No. 731 with 75 watt lamps are countersunk in the tops of the circassian walnut cases to direct the light to the ceiling, care being exercised to have the openings cut so as to form an overlay that would cut off the light from the pilasters and sidewall, thus illuminating the ceilings only. Newel posts in the rear of the store, under the mezzanine floor contain X-Ray reflectors No. EC-14. These were supplemented by four more No. 731 reflectors, sunk in the rear wallcases and four No. E-61 reflectors in the top of the partition which separates the small office from the main show room.

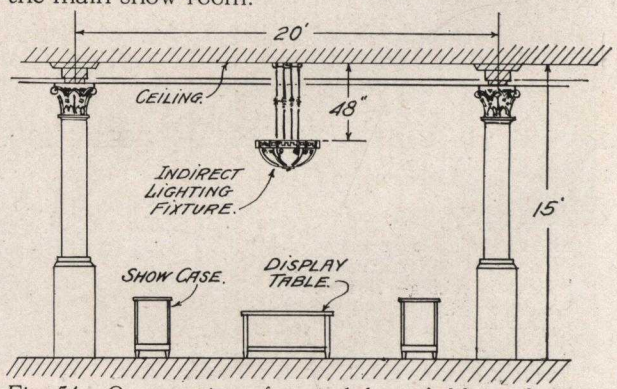


Fig. 54. Cross section of typical bay of Miller & Paine Department Store, Lincoln, Nebraska.

Small Stores

The small stores can be just as attractively lighted as the large department stores, and economically. Only four fixtures are used to illuminate the haberdashery store shown below. The room is 31 feet wide and 36 feet long, the ceiling 12 feet high.

Fig. 56. The Shelley Store, Milwaukee, Wis.

Each fixture contains one E C 344 X-Ray reflectors with 300-watt lamps, making the wattage consumption 1.03 watt per square foot. On page 87 the details of the lighting of another small store are given.

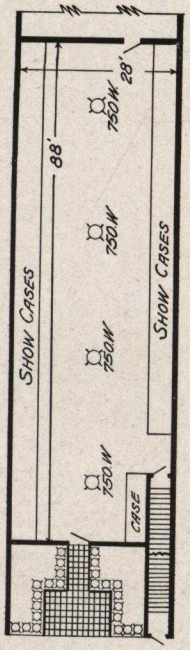


Fig. 56. Plan of typical small store showing proper location of lighting outlets and reflectors for show windows.

Fig. 57. Winters jewelry store, Minneapolis, Minn.

Winter's Jewelry Store

The illustration shown above pictures the interior of Winter's Jewelry Store, Minneapolis, Minn. The general lighting is accomplished by means of X-Ray Indirect Lighting fixtures, supplemented by local showcase units which consist of X-Ray Reflectors placed inside of ornamental silk shades, and suspended above the showcases by a bracket. The local light provides an intense illumination at points where it is desired to display trays containing various articles of jewelry to the customer.

WINTER'S JEWELRY STORE
MINNEAPOLIS, MINN.
Salesroom

GENERAL NOTES:
Size of room—22 x 60 feet.
Floor area—1320 square feet.
Height of ceiling—16 feet.
Number of fixtures—5.
Lamps per fixture—One 500-watt.
Type of reflector—X-Ray No. EC-345.
Wattage consumed—1.9 watts per square foot.
Fixtures suspended—42 inches.
Fixtures spaced—12 feet apart.

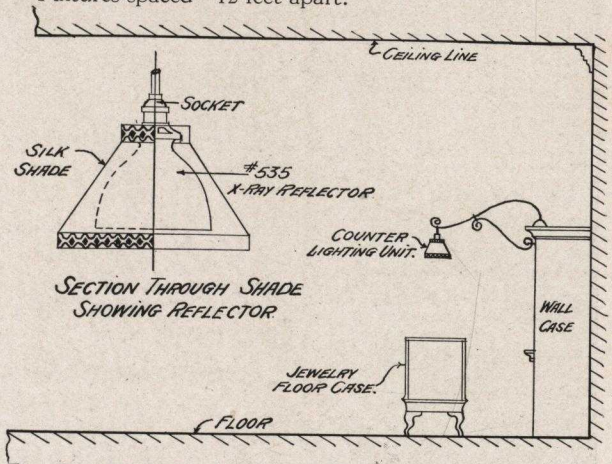


Fig. 58. Diagram of counter lighting unit for Jewelry stores to supplement general illumination.

Fig. 59. Shoe store, S. J. Thomas & Company, Norfolk, Va.

Fig. 60. Display room, Overland Motor Company, Kansas City, Missouri.

DISPLAY ROOMS

Some classes of interiors combine the purposes of a display room with those of the store and office. This is true of auto show rooms and offices of manufacturers' representatives who carry a sample display of the company's products.

Indirect lighting is especially suitable for the display room where the finish of goods is to be brought out in its truest character. Beautiful finishes and highly polished surfaces are most advantageously displayed under diffused lighting. Direct light tends to produce shadows, reflections, and spots where in reality they do not appear on the surface, thus showing up the product in an inferior way.

The methods for lighting display rooms are just as varied as for other classes of interiors. On page 108 an especially interesting treatment of an auto display room is detailed.

OVERLAND MOTOR CO., KANSAS CITY, MO.
Display Room

GENERAL NOTES:

Size of room—about 65 x 128 feet.
Floor area—8320 square feet.
Height of ceiling—15 feet.
Number of fixtures—15.
Lamps per fixture—four 150-watt.
Type of reflector—X-Ray No. EC 15.
Wattage consumed—1.10 watts per square foot.
Fixtures suspended—18 inches.
Fixtures spaced—about 20 feet apart.

S. J. THOMAS & CO., NORFOLK, VA.
Shoe Store

GENERAL NOTES:

Size of room—18 feet 6 inches x 100 feet.
Floor area—1850 square feet.
Height of ceiling—21 feet.
Number of fixtures—6.
Lamps per fixture—One 400-watt.
Type of reflector—X-Ray EC-345.
Wattage consumed—1.3 watts per square foot.
Fixtures suspended—72 inches.
Fixtures spaced—16 feet 8 inches apart.

Fig. 61. Confectionary shop, Pulakos store, Erie, Pa.

SHOPS

Candy and Chocolate Shops, Tea Rooms, Beauty Parlors and many interiors of this class are most attractively lighted by indirect illumination. In the majority of cases hanging fixtures from the ceiling are employed. Exclusive effects can be obtained by lighting from other than ceiling outlets, as shown in the case of the Barbara Fritchie Candy Shop shown on page 104. No more wattage is required than with ceiling fixtures.

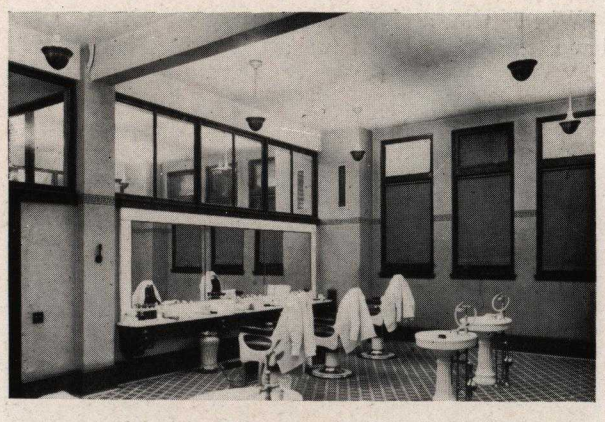


Fig. 62. Barber shop, Armour & Co., Chicago, Ill.

ARMOUR & CO., CHICAGO, ILL.
Barber Shop

GENERAL NOTES:

Size of room—21 x 35 feet.
Floor area—735 square feet.
Height of ceiling—13 feet 6 inches.
Number of fixtures—8.
Lamps per fixture—One 150-watt.
Type of reflector—X-Ray No. EC-12.
Wattage consumed—1.63 watt per square foot.
Fixtures suspended—24 inches.
Fixtures spaced—14 feet apart.

Fig. 63. Men's Lounge—Palace Hippodrome Theater
Kirchoff & Rose, Architects, Milwaukee, Wis.

Fig. 65. Lodge Room—W. D. Luckie Lodge Masonic Building
Hentz, Reid & Adler, Architects, Atlanta, Ga.

CLUBS

Comfort should characterize every feature that the club has to offer to its membership. Restful illumination is one of the most essential comforts.

The lounge of the Union League Club of Chicago offers an interesting example of the effect of lighting upon the comfort of the surroundings. (See page 81.)

When the archaic assemblage of glaring glass bowls was discarded for artistic indirect fixtures that properly control and diffuse the light, there was more than an improvement in the fixtures—the new light is glareless, clear and restful.

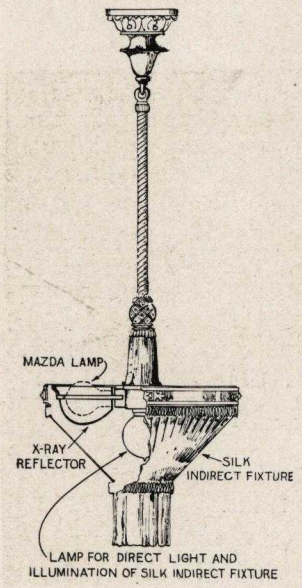


Fig. 64. Sketch of Luminous Type Fixture for Men's Lounge

The fixture is the X-Ray luminous bowl type, other forms of which are shown in both the photographs at the top of this page. The manner of lighting bowl and how fixtures can be equipped to give a flood of indirect light without the annoyance of glare is described more fully on page 23.

Lighting for clubs from other than ceiling fixtures is illustrated on page 89, where typical examples are given of pedestal lighting and the effect produced with side wall lighting boxes containing X-Ray reflectors.

The fixture design in figure 64 was made up especially for the Men's Lounge of the Palace Hippodrome Theater, Milwaukee, Wis. This design combines the artistic lines of the Elizabethan period with the utilitarian features that go to make up a practical lighting unit.

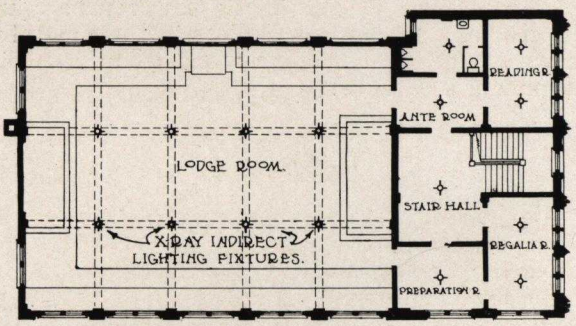


Fig. 66. Plan of Third Floor—Lodge Room
W. D. Luckie Lodge Masonic Building, Atlanta, Ga.

W. D. LUCKIE BUILDING, ATLANTA, GA.

Lodge Room

GENERAL NOTES:

Size of Lodge Room—48 x 70 feet.
Floor Area—3360 square feet.
Height of Ceiling—15 feet.
Number of Fixtures—8
Lamps per Fixture—4 100-Watt Madza "C."
Bowls hang 48 inches from ceiling.
Wattage Consumed—.95-Watt per square foot.

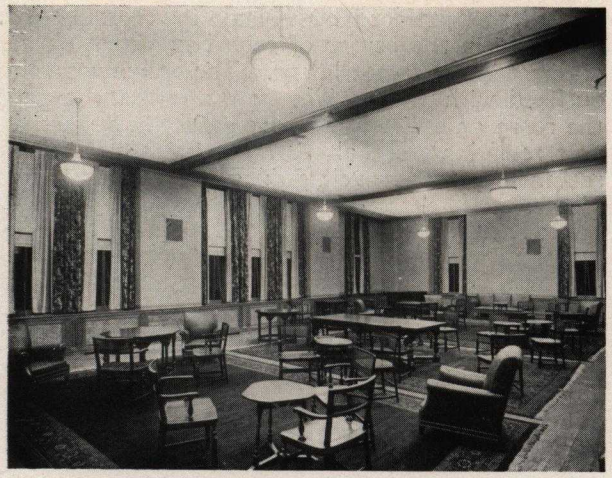


Fig. 67. Club room, Detroit Daily News Bldg., Detroit, Mich. Albert Kahn, Architect; Ernest Wilby, Associate.

Ball Room

It is of interest to note that the estimated cost of the fixture installation for direct lighting in the ball-room was practically twice the sum paid for the indirect lighting installation. The South Shore Country Club of Chicago is oneof the country's largest social institutions. The ball room or assembly room occupies a separate building and is connected to the main club house by agarden foyer which is illustrated on page 89. Three large fixtures furnish all of the illumination for the main ball room area. The fixture is of an openwork design, lined with red silk, which shows its color by the light reflected upon the ceiling. The promenade surrounding the ball room is lighted in a similar manner by fixtures containing a single units uspended from the center of each ceiling panel.

Billiard Room

One X-Ray indirect lighting fixture over the center of each billiard table gives excellent results. An example of the successful use of this system is shown in the illustration of the Y. M. C. A. billiard room of Beliot, Wisconsin. Each fixture contains a 300-watt lamp.

DETROIT DAILY NEWS BUILDING

Rest Room

GENERAL NOTES:

Size of room—32 x 48 feet.
Floor area—1536 square feet.
Height of ceiling—14 feet.
Number of fixtures—6.
Lamps per fixture—1-300 watt.
Type of reflector—X-Ray No. EC-344.
Wattage consumed—1.17 watts per square foot.
Fixture suspended—48 inches from ceiling.
Fixtures spaced—16 feet apart.

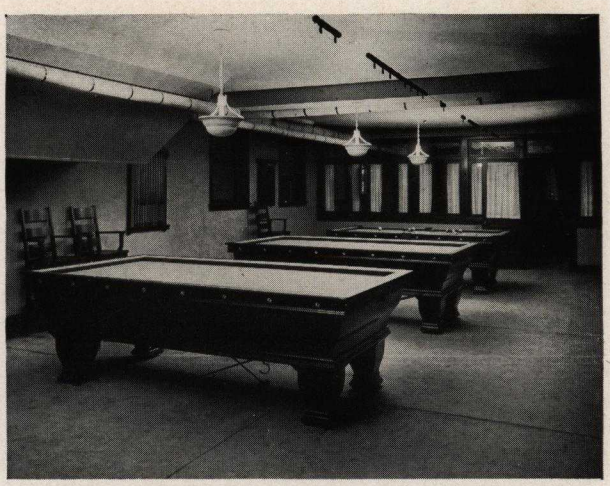


Fig. 68. Billiard room, Beloit Y. M. C. A., Beloit, Wisconsin. Shattuck & Hussey, Architects, Chicago, Ill.

SOUTH SHORE COUNTRY CLUB, CHICAGO

Ball Room

GENERAL NOTES:

Size of room—86 x 124 feet.
Floor area—10664 square feet.
Height of ceiling—At center, 28 feet; on sides, 20 feet.
Number of fixtures—3 large, 28 small.
Lamps per fixture—Large, 23 100-watt; small, one 100-watt.
Type of reflector—X-Ray EC-15.
Wattage consumed—Dance floor only, 1.11 watts per square foot; entire floor area, .91 watt per square foot.
Fixtures suspended—Large, 72 inches; small, 30 inches.
Fixtures spaced—33 feet apart over dance floor.
12 feet apart over promenade.

Fig. 69. Ball room, South Shore Country Club, Chicago, Ill. Marshall & Fox, Architects.

HOTELS

Fig. 70. Exchange floor, Hotel Traymore, Atlantic City, N. J. Price & McLanahan, Architects, Philadelphia, Pa.

Traymore Hotel

The Traymore is America's greatest seaside hotel. The main exchange or grand promenade as it is usually called is illustrated above. It is the most important room in the hotel, containing the offices and gaining access to most of the public rooms. It is gorgeously decorated. The walls and columns are plastered in a cream tone. The ceiling is white plaster with touches of yellow and gold in the indirect lighting fixtures. The diagram shows the unique type of fixture installed in the main exchange.

The stairway at one end of the main exchange floor leads up to a mezzanine floor containing a fountain room, the details of the lighting of which are shown on page 106. The fountain room continues the general character of the grand promenade, though its proportions and details are considerably different.

Auditorium Hotel Lobby

One of the pioneer installations of commercial indirect illumination was made in the public lobby of the Auditorium Hotel of Chicago, an interior that is familiar to thousands. Soon after the introduction of the Tungsten lamp the direct lighting system was replaced by X-Ray indirect lighting. Formerly in the center of each bay was a cluster of direct incandescent lamps. The arches were also outlined with them. The new arrangement gave the room an entirely different aspect in attractiveness, restfulness, and also in an artistic way, entirely satisfactory to a traveling public that is difficult to please.

HOTEL TRAYMORE, ATLANTIC CITY, N. J.

Exchange Floor

GENERAL NOTES:

Size of typical bay—19 x 22 feet.
Floor area—418 square feet.
Height of ceiling—18 feet 3 inches.
Number of fixtures—1 per bay.
Lamps per fixture—Eight 100-watt.
Type of reflector—X-Ray EC-15.
Wattage consumed—1.9 watts per square foot.
Fixtures suspended—45 inches.
Fixtures spaced—19 to 22 feet apart.

AUDITORIUM HOTEL, CHICAGO, ILL.

Main Lobby

GENERAL NOTES:

Size of room—45 feet x 92 feet 6 inches.
Floor area—4163 square feet.
Height of ceiling—24 feet.
Number of fixtures—12.
Lamps per fixture—Five 100-watt.
Type of reflector—X-Ray EC-15.
Wattage consumed—1.44 watts per square foot.
Fixtures suspended—64 inches.
Fixtures spaced—approx. 16 to 23 feet apart.

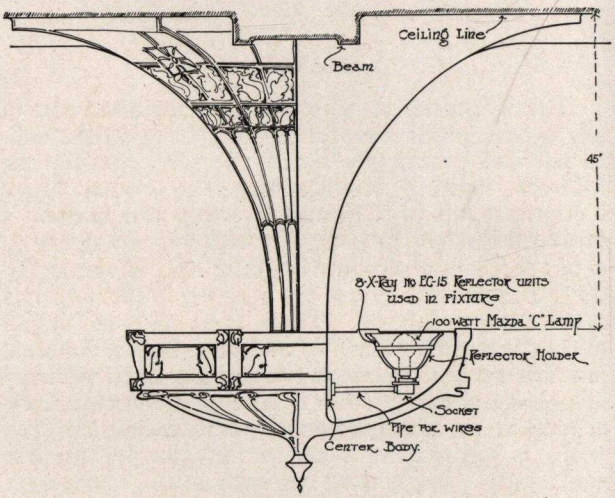


Fig. 71. Large lighting pendant in main exchange, Hotel Traymore.

Fig. 72. Lobby Auditorium Hotel, Chicago, Ill. Louis H. Sullivan, Architect.

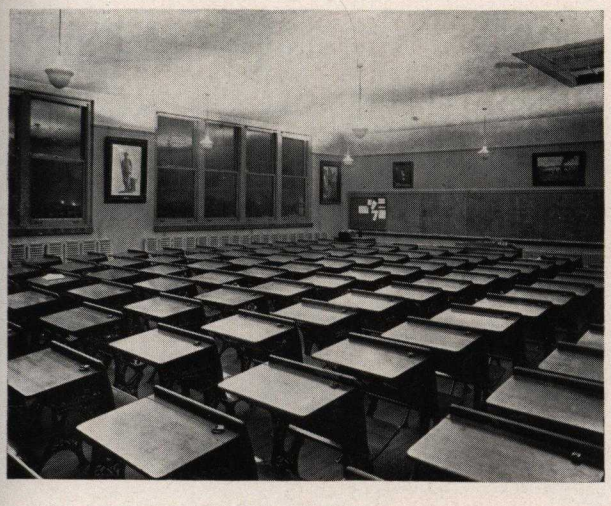


Fig. 73. Study room, Minneapolis high school, Minneapolis, Minn. Stebbins & Haxby, Architects.

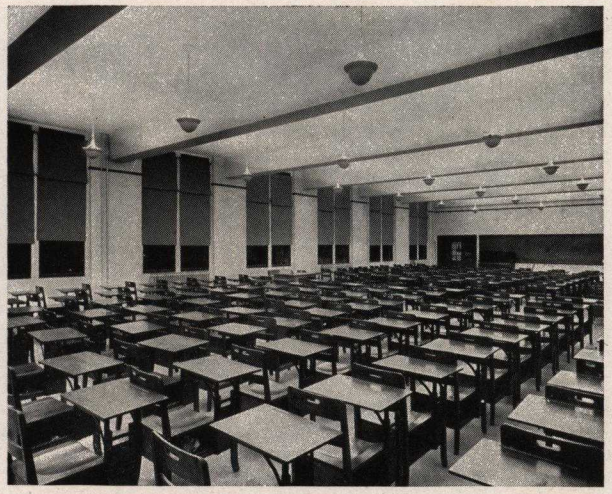


Fig. 74. Study room, Lincoln high school, Lincoln, Nebraska. Burlinghof & Davis, Architects.

SCHOOLS AND COLLEGES

Undoubtedly, the school next to the home is the place to begin conserving the vision of our future generations by supplying comfortable illumination.

No form of education can be said to be truly successful if it involves any serious ill effect to the physical, mental, or moral welfare of persons which it is to benefit. School room illumination which is not altogether hygienic is a detriment to the student. His eyesight suffers from it, and in the last analysis is a loss to the public at large and to the nation.

A report to the Journal of the Board of Education of the State of New York for 1908 states:

"It is a well established fact that myopia (short-sightedness) among children grows in frequency of occurrence with each completed school year, and that it increases in frequency as additional book work and written work are imposed on the pupils by school requirements.

"As only 5% of the cases of myopia are believed to be due to unpreventable and uncontrollable causes, and as a majority of cases of myopia are more or less directly traceable to eye-strain in school it becomes a matter of duty for parents and school authorities to remove or modify as far as possible all controllable conditions that tend to impair eyesight during school years. It is impossible to dispense with the teaching or reading and writing, but it is possible to improve the physical conditions under which reading and writing are being done."

Therefore, the responsibility for the selection of a lighting system which will decrease eye troubles assumes great importance. Screened or shaded light sources should be universally adopted, bare lamps with their piercing brilliant rays mar the eyesight of children, rasp their nerves and contribute many recruits to the ranks of unwilling eyeglass-wearers.

Lighting Requirements

The illumination requirements of different rooms of a school building vary widely, depending on the exact purpose for which the room is to be used. The

EAST HIGH SCHOOL, MINNEAPOLIS, MINN.

Class Room

GENERAL NOTES:

Size of room—36 x 49 feet.
Floor area—1764 square feet.
Height of ceiling—12 feet.
Number of fixtures—9.
Lamps per fixture—1-150 watt.
Type of reflector—X-Ray No. EC-12.
Wattage consumed—.77 watts per square foot.
Fixtures suspended—36 inches from ceiling.
Fixtures spaced—12 feet apart.

LINCOLN HIGH SCHOOL, LINCOLN, NEBR.

Study Room

GENERAL NOTES:

Size of room—34 x 79 feet.
Floor area—2686 square feet.
Height of ceiling—14 feet.
Number of fixtures—21.
Lamps per fixture—1-150 watt.
Type of reflector—X-Ray No. EC-12.
Wattage consumed—1.2 watts per square foot.
Fixtures suspended—36 inches from ceiling.
Fixtures spaced—about 11 feet apart.

study rooms and offices where close eye work is carried on very exacting conditions must be met and intensities must be provided which cause the least eye fatigue. In the lecture hall or auditorium a less intensity of light may be used than that required for a study room.

Class Rooms

Indirect lighting is particularly well adapted to the class rooms. It will supply a uniform illumination for each desk. It will be impossible for a pupil to cast annoying shadows on his neighbor's desk. There must be no visible light sources interposed between the eyes of the scholar and the blackboard. There must be no glare reflected into the eyes from polished desks, glossy papers, mirrors, etc. One of the special advantages of indirect lighting in the class room is that marks on the black board across the room are easily seen from any position.

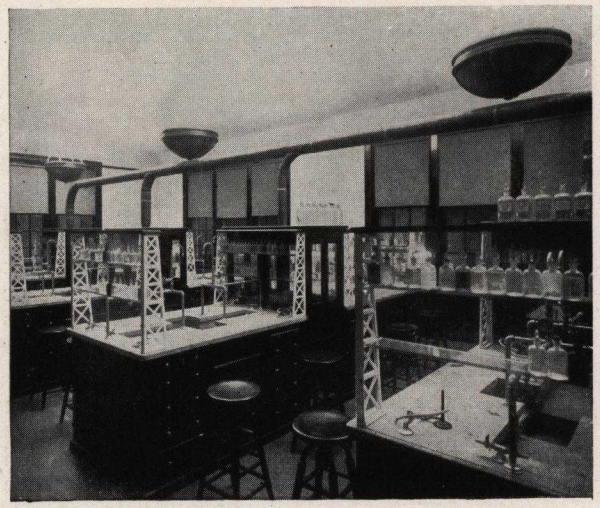


Fig. 75. Chemical laboratory, Boys' high school, New Orleans, La. E. A. Christy, Architect.

The recommended intensities of light for various rooms in the school and college buildings are given in table number 2 on page 34. By referring to this table we find that the value recommended for class and study rooms is 4 foot candles. This is sufficient for close book work. Its value is also correct for rooms used as chemical, physical, or biological laboratories and for domestic science rooms.

BOYS' HIGH SCHOOL, NEW ORLEANS, LA.
Laboratory

GENERAL NOTES:

Size of room—25 x 41 feet.
Floor area—1025 square feet.
Height of ceiling—13 feet.
Number of fixtures—3.
Lamps per fixture—Five 100-watt.
Type of reflector—X-Ray EC-15.
Wattage consumed—1.45 watts per square foot.
Fixtures suspended—36 inches.
Fixtures spaced—14 feet apart.

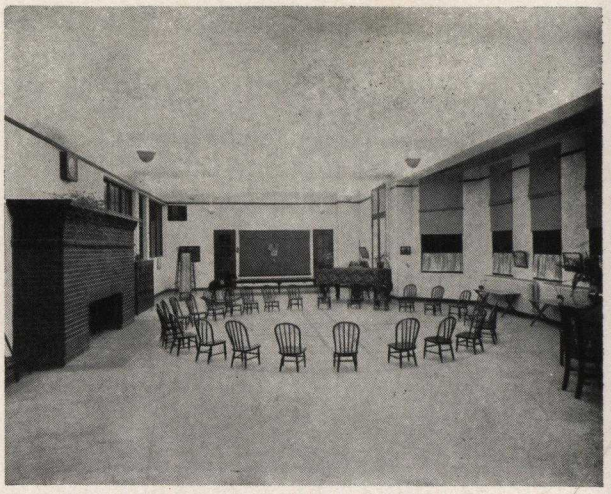


Fig. 76. Kindergarten room, Bancroft school, Lincoln, Nebraska. Burlinghof & Davis, Architects.

Libraries and Reading Rooms

Libraries and study places must be illuminated with great care and practically the same quality of illumination, in so far as light distribution and light diffusion are concerned, must be provided as suggested for classrooms in schools. In the case of the study room or library, however, where continued close application is required for a longer period, uniform, well-diffused light of about 4½ foot candle intensity should be provided on the tables and desks.

A catalogue room, equipped with properly designed indirect lighting fixtures, will require no local units at the card cases. Diffused illumination penetrates into the drawers making it unnecessary to remove the cards.

Fig. 77. Library, East high school, Minneapolis, Minn. Stebbins & Haxby, Architects

An interesting installation for the lighting of bookstacks is shown on page 188, where the X-Ray Scoopette reflector is employed, using a small 15 watt Mazda lamp.

A unique method of bookstack lighting is given on page 98. Here the illumination is secured by using special lighting units placed upon the top of the bookstacks. The light is thrown to the ceiling and from there diffused throughout the aisles and spaces between the stacks.

EAST HIGH SCHOOL, MINNEAPOLIS, MINN.

Library

GENERAL NOTES:

Size of room—24 x 36 feet.
Floor area—864 square feet.
Height of ceiling—12 feet.
Number of fixtures—6.
Lamps per fixture—One 150-watt.
Type of reflector—X-Ray EC-12.
Wattage consumed—1.05 watts per square foot.
Fixtures suspended—36 inches.
Fixtures spaced—12 feet apart.

Fig. 78. Branch of public library, Milwaukee, Wis.

The school building includes many kinds of rooms each of which requires individual treatment as far as lighting is concerned. The offices and commercial departments should be lighted in the same manner as ordinary business offices, see page 39. Auditorium and assembly hall lighting is described on pages 63 and 89. Drawing rooms and drafting rooms need an intense and well-diffused illumination. Examples are given on page 57. The lighting of the gymnasium as well as the work shops and manual training departments is best accomplished by direct illumination with units placed at or near the ceiling. Bench lights and drop cords should not be installed. In the direct lighting section of this book many examples are given of proper lighting for gymnasiums and shops.

Fig. 79. Periodical reading room, Library of Congress, Washington, D. C.

PERIODICAL READING ROOM

The periodical reading rooms on the first floor of the Congressional Library, Washington, D. C. is illustrated above. Over 1,000 newspapers are currently received, including about 275 foreign newspapers, and of these 375 are bound and shelved. The files of American newspapers are very extensive. The collection of the newspapers of the eighteenth century is perhaps the largest in America.

The reading room for periodicals occupies the south side of the building on the main floor. It has seats for 250 readers and 400 newspapers and 3500 magazines to which readers have direct access are kept in this room. The use of X-Ray indirect lighting in this room makes it unnecessary to use any localized light of any kind. Desk lamps and reading lamps are eliminated.

The ceiling of the room is finished in light cream. The walls are buff with a slight pinkish tint.

Thirty fixtures furnish all of the illumination for the entire area.

CONGRESSIONAL LIBRARY
WASHINGTON, D. C.

Periodical Reading Room

GENERAL NOTES·

Size of room—36 x 225 feet.
Floor area—8100 square feet.
Height of ceiling—18 feet.
Number of fixtures—30.
Lamps per fixture—One 400-watt.
Type of reflector—X-Ray No. EC-345.
Wattage consumed—1.48 watts per square foot.
Fixtures suspended—42 inches.
Fixtures spaced—15 feet apart.

INDIRECT LIGHTING IN THE INDUSTRIES

Fig. 80. Assembling department, Stewart-Warner Company Chicago, Ill. L. G. Hallberg & Co., Architects.

Until recently the conditions which existed in industrial buildings have made the direct lighting system practically imperative. In the modern type of factory building, however, the walls and ceiling are white and kept in good condition. The X-Ray system of illumination can be used successfully and economically. This lighting treatment for factories and workrooms is brought about, not only by the modern concrete building construction, but also by the fact that in the newer industrial plants the ceilings are unobstructed by shafting and belts, since most of the modern machinery is operated by individual motors.

Indirect lighting is especially suitable for textile mills, printing plants, and other classes of interiors where intricate operations require diffused light.

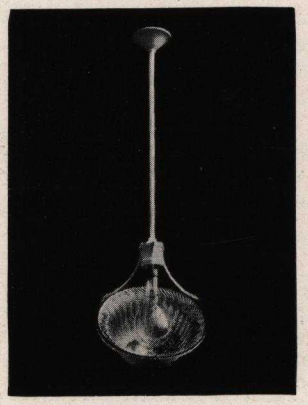


Fig. 81. Typical fixture for indirect lighting in industrial plants—unhooked for cleaning.

In addition to the example shown on this page, an interesting installation is detailed on page 83.

A fixture especially designed for industrial use is shown below. This unit can be readily attached to an ordinary outlet box. It has a zinc plate or sherardized finish and can be lowered for the easy cleaning of the lamp and the reflector.

An inspection of the data for the various installations shown will disclose the fact that this system of lighting is economical for industrial plants.

STEWART-WARNER SPEEDOMETER CORP. CHICAGO, ILL.

Assembly Department

GENERAL NOTES:

Size of typical bay—18 x 18 feet.
Floor area—324 feet per bay.
Height of ceiling—10 feet 6 inches.
Number of fixtures—319.
Lamps per fixture—One 400-watt.
Type of reflector—X-Ray No. EC-344.
Wattage consumed—1.23 watts per square foot.
Fixtures suspended—30 inches.
Fixtures spaced—18 feet apart.

Fig. 82. Sewing room, Wise Brothers Company, Baltimore, Md. Parker, Thomas & Rice, Architects.

WISE BROTHERS, BALTIMORE, MD.

Sewing Machine Department

GENERAL NOTES:

Size of typical bay—16 feet 9 inches x 21 feet 6 inches.
Floor area—360 square feet.
Height of ceiling—12 feet 6 inches.
Number of fixtures—2 per bay.
Lamps per fixture—One 300-watt.
Type of reflector—X-Ray EC-345.
Wattage consumed—1.68 watts per square foot.
Fixtures suspended—36 inches.
Fixtures spaced—As shown in plan on page 155.

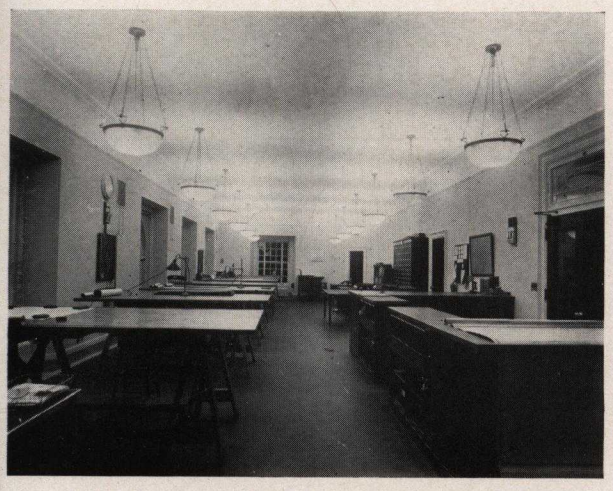


Fig. 84. Drafting room, Hartford City Hall, Hartford, Connecticut. Davis & Brooks, Architects.

Fig. 85. Drawing room, Lincoln high school, Lincoln, Nebraska. Burlinghof & Davis, Architects.

DRAFTING ROOMS

The drafting room is included in the second class of interiors mentioned on page 29; interiors in which a uniform and extremely diffuse and shadowless illumination is required.

One of the most severe tests to which a lighting system can be put is in the drafting room.

The draftman's vision must be conserved in every possible way, as the already great strain on his eyes, due to the fine accurate work necessary, should not be added to by a poorly designed or ill-advised lighting system.

The ability of the draftsman to continue his exacting work without fatigue is very much increased when he works under Indirect Lighting.

AMERICAN CAR & FOUNDRY COMPANY NEW YORK CITY

Drafting Room

GENERAL NOTES:

Size of room—32 x 50 feet.
Floor area—1600 square feet.
Height of ceiling—10 feet 6 inches.
Number of fixtures—16.
Lamps per fixture—1-300 watt.
Type of reflector—X-Ray No. EC-345.
Wattage consumed—3 watts per square foot.
Fixtures suspended—30 inches from ceiling.
Fixtures spaced—10 x 11 feet apart.

The uniform distribution of light obtainable with this system is ideal for the drafting room. Proper lighting will maintain the draftman's efficiency, a point in office management which is often overlooked.

With a proper system, no desk lamps are required. The fixtures are overhead and out of the way. The tables may be placed in any position desired.

LINCOLN HIGH SCHOOL, LINCOLN, NEB.

Art Room

GENERAL NOTES:

Size of room—44 x 80 feet.
Floor area—3520 square feet.
Height of ceiling—13 feet 6 inches.
Number of fixtures—15.
Lamps per fixture—1-200 watt.
Type of reflector—X-Ray No. EC-12.
Wattage consumed—.85 watts per square foot.
Fixtures suspended—36 inches from ceiling.

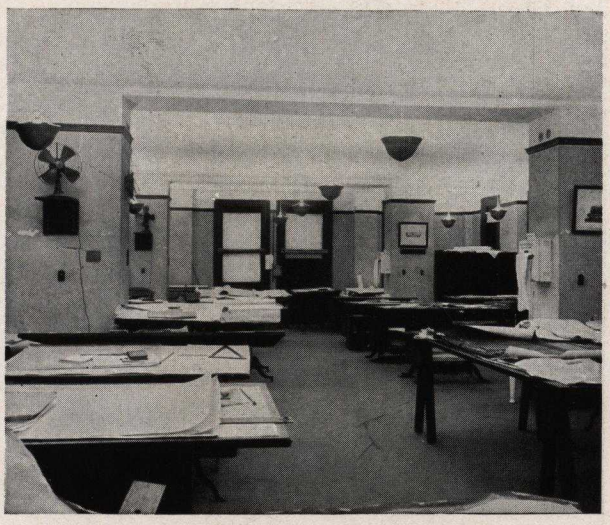


Fig. 86. Drafting room, American Car & Foundry Co., New York City.

Fig. 87. Eberhart Memorial Church, Mishawaka, Indiana, Badgley & Nicklas, Architects, Cleveland, Ohio.

CHURCHES

The illumination for church interiors should have the qualities of comfort and restfulness.

A poorly designed lighting system affects both the minister and his congregation. He gazes into blazing lights instead of into the faces of his parishioners. They, in turn, suffer from eye fatigue, drowsiness and headaches, caused by those same improperly concealed lamps, and, because of the irritation, fail to sustain an interest in the service.

On the other hand, good lighting in the church means an attractive church, and an attentive audience.

When one of the earliest installations of X-Ray indirect lighting was made, the fitness of this system for the church interior was very aptly expressed, thus: *A visible light source in the house of worship will soon be considered as much out of place as a coarse word, loudly spoken.*

Fig. 88. Vestibule, Timothy Eaton Memorial Church, Toronto Canada. Wickson & Gregg, Architects.

The many methods of lighting this class of interior makes possible the design of installation which will blend in with and sometimes become a part of the architecture of the interior.

Individual cases require separate methods of treatment and permit the exercise of a wonderful amount of ingenuity and skill on the part of the designer.

Eberhardt Memorial Church

The illustration on the opposite page shows a very striking example in which the lighting equipment is made a part of the architecture. The compone fixtures are gothic in design and special provision is made in the ceiling construction for the reception of the fixture canopy. Each of the large fixtures suspended from the main vaulted ceiling is equipped with a windlass which permits lowering the fixture for cleaning and renewal of lamps.

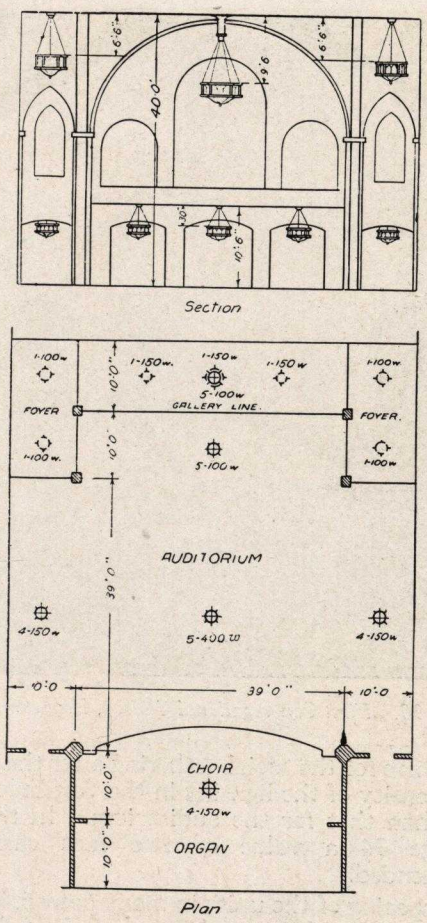


Fig. 89. Diagram showing lighting arrangements for Eberhardt Memorial Church, Mishawaka, Ind.

The Vestibule or Foyer

The illustration above indicates how the vestibule and foyer can be made inviting by means of indirect illumination. The diffused lighting not only brings out the full value of the architectural treatment, but also helps to produce an attractive

EBERHART MEMORIAL CHURCH, MISHAWAKA, IND.

Auditorium

GENERAL NOTES:

Size of auditorium—59 x 39 feet.
Floor area—2300 square feet.
Height of ceiling—40 feet.
Number of fixtures—3.
Lamps per fixture—Center, 5 400-watt; sides, 4 150-watt.
Type of reflector—X-Ray EC-344, and EC-15.
Wattage consumed—1.4 watts per square foot.
Fixtures suspended—Center, 114 inches; sides, 78 inches.
Fixtures spaced—24 feet 6 inches apart.

Fig. 90. First Congregational Church, Evanston, Ill.

atmosphere for the social gathering after the service. The intensity of the lighting in the vestibule can be lower than that for the auditorium. In the table on page 34 a value of two foot candles is recommended.

The spacing of the units in many cases is dependent upon the architectural features of the building as well as the dimensions. It is not always possible to space the units symmetrically for uniform illumination since the location of the fixtures is determined by the manner in which the ceiling area is divided architecturally.

Lighting from cornices and brackets has been successfully applied in numerous churches. Interesting examples of these methods are given on page 90.

X-Ray Indirect Lighting has solved the problem for many cases, but it cannot be installed in all churches, especially those interiors having dark ceilings, heavily beamed.

While direct lighting is necessary to efficiently illuminate such churches, the principle of illumination from concealed sources can be carried out. An example of this kind is shown on page 158.

FIRST CONGREGATIONAL CHURCH
EVANSTON, ILL.

Auditorium

GENERAL NOTES:

Size of room—70 x 70 feet.
Floor area—4900 square feet.
Height of ceiling—40 feet.
Number of fixtures—1.
Lamps per fixture—Ten 400-watt.
Type of reflector—X-Ray No. EC-344.
Wattage consumed—.81 watt per square foot.
Fixtures suspended—192 inches (16 feet).

First Congregational Church

The First Congregational Church of Evanston, Illinois, illustrates what can be done in the relighting of old churches. This auditorium was formerly lighted by means of a large chandelier carrying 38 exposed incandescent lamps. The glare from this fixture caused much discomfort to the audience, especially those seated in the balcony. The condition was entirely changed when a single large indirect lighting fixture was installed. The fixture bowl contains ten 400-watt lamps and provides an easy reading light for the entire auditorium space, including the main floor, balcony, and platform. Conditions similar to those that prevailed in the Evanston Church are found in many public auditoriums. These conditions can be, however, easily corrected by proper installation of X-Ray indirect lighting.

Social Rooms

Although the auditorium is the main room of the church building, other rooms are equally well taken care of by means of the indirect lighting system. It is especially suitable for social rooms, pastor's study, dining rooms, kitchen, Sunday school rooms, choir rooms, vestibule, and for the parish house which is often in connection with the church edifice.

Many of the larger churches have a gymnasium. The lighting for this class of interior may be planned in accordance with the information given on page 140.

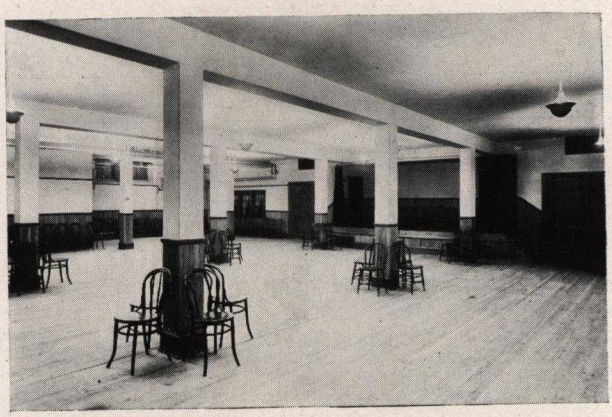


Fig. 91. Social hall, Evangelical Lutheran Church, Baltimore, Md.

FIXTURES FOR GOTHIC CHURCHES

It is important that buildings of a certain distinct type of architecture should have lighting fixtures consistent with that style.

The fact that indirect illumination is to be used in an interior, does not hamper the designer or the architect in working out a lighting unit which will fit the individuality of the building. The gothic

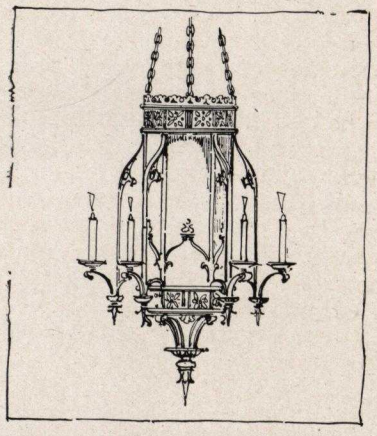


Fig. 92. Gothic fixture designed 1500 A. D.

lantern illustrated on this page is a model which is beautifully adapted for use in a building of gothic architecture. It is just as artistic and harmonious and as true to its type as the lantern of the sixteenth century with its flickering candles.

The fixture can be equipped with opal or colored glass panels in the sides which makes the lantern

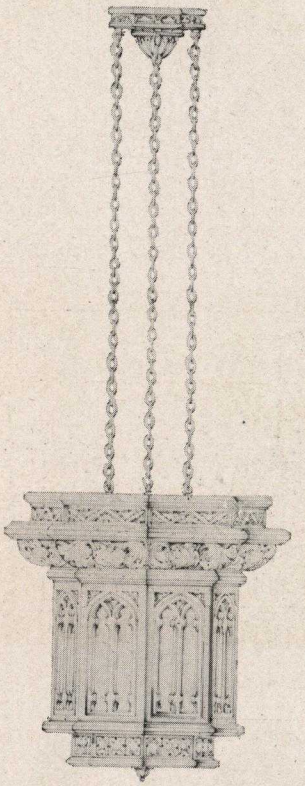


Fig. 94. Lantern fixture for Gothic churches.

the type known as the luminous indirect. The diagrams below illustrate how the interior equipment of the lantern can be entirely changed to conform to an indirect lighting or a direct lighting installation.

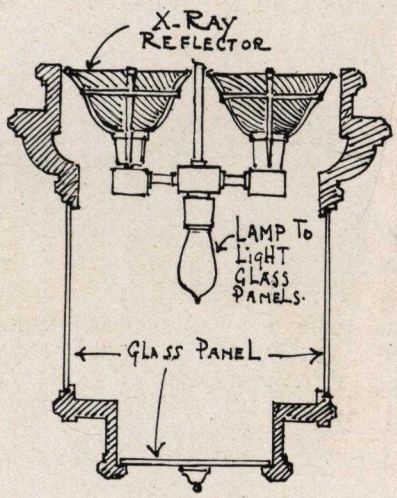


Fig. 93. Sectional view of Gothic lantern fixture showing interior arrangements for indirect lighting.

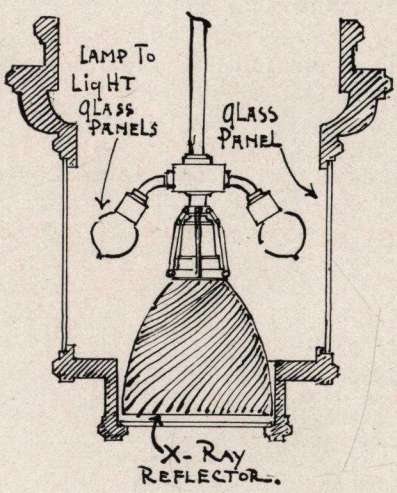


Fig. 95. Sectional view of Gothic lantern fixture showing interior arrangements for direct lighting.

Fig. 96. Auditorium, Boys' High School, New Orleans, La. E. A. Christy, Architect.

AUDITORIUMS

In considering the proper illumination of the auditorium the decorative effect, many times is of equal importance with the securing of the best quality of artificial lighting. It is always important, of course, that all bare and excessively bright light sources be entirely concealed from the audience.

When indirect lighting is used there are two general methods, one from hanging bowls and the other from a cove or cornice or a series of projecting wall urns or lighting boxes. The latter methods are illustrated and described on pages 90 and 95.

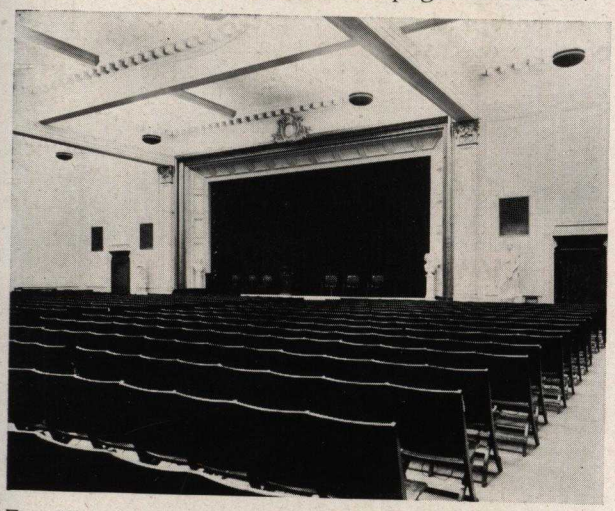


Fig. 97. Auditorium, Bangor high school, Bangor, Maine, A. Parker Crowell, Architect.

In many auditoriums, especially those connected with schools, frequent use is made of the stereopticon. It is, therefore, important to provide a means of dim lighting for use while the stereopticon is employed. The dim lighting will enable the audience to locate seats easily and move about with a minimum of noise and confusion. This is easily arranged by using two circuits so that by the turn of the switch the auditorium may be flooded with a clear daylight effect, or by the turn of another switch suffused with a dim, soft glow, ample for every purpose, but not interfering with the clearness of the pictures on the screen.

BOYS' SCHOOL, NEW ORLEANS, LA.

Auditorium

GENERAL NOTES:

Size of auditorium—52 x 73 feet.
Floor area—3796 square feet.
Height of ceiling—26 feet.
Number of fixtures—15.
Lamps per fixture—Center row, 7 100-watt; sides, 5 60-watt.
Type of reflector—X-Ray EC-15.
Wattage consumed—1.71 watts per square foot.
Fixtures suspended—62 inches.
Fixtures spaced—14 feet 6 inches apart.

Fig. 98. Rugby school, Rugby, England. Sir Thomas Jackson, Architect. Installation made by British Thomson-Houston Co., Ltd.

RUGBY SCHOOL, RUGBY, ENGLAND

Auditorium

GENERAL NOTES:

Size of auditorium—38 x 124 feet.
Floor area—4712 square feet.
Height of ceiling—36 feet.
Number of fixtures—3: 1 center, 2 sides.
Lamps per fixture—Center, 7 300-watt; sides, 9 100-watt.
Type of reflector—X-Ray EC-344 and EC-15.
Wattage consumed—.83 watt per square foot.
Fixtures suspended—Center, 72 inches; sides, 48 inches.
Fixtures spaced—34 feet apart.

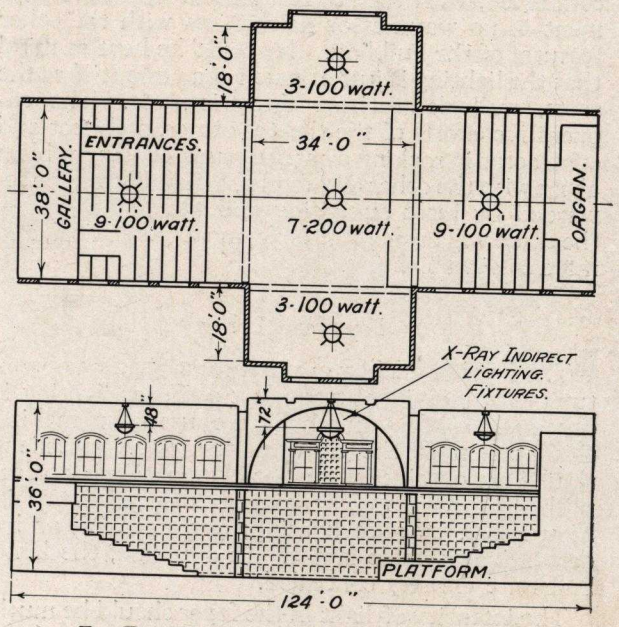


Fig. 99. Plan and section of the Rugby school.

THEATERS

As the theater is used at night, light is therefore the best means to make the theater attractive. The effective use of light is a wonderful power in the hands of the theater owner for advertising effect and for the comfort of his patrons. It is not necessarily the brilliantly lighted theater that has the rush of patrons. The light must be used rationally in order to make it work to the best effect.

Fig. 100. The Entrance—California Theatre, San Francisco California. Alfred H. Jacobs, Architect. Lighted by fixtures containing X-Ray reflectors.

It is too often the case in the lighting of theaters that the fixtures are selected after the building is completed, with the result that the lighting equipment in no way fits or harmonizes with the other features of the building. It should be kept in mind that the lighting is just as much of an essential as the seats, wall decorations, draperies, etc. The co-operative efforts of the theater owner, architect and contractor in making a careful study of this problem along with the other details of the building will be rewarded by most surprising and pleasing results—the effect will be more suitable, more economical, and more efficient lighting.

Foyer and Lobby

The foyer and lobby of the theater gives an opportunity for individual treatment as far as lighting is concerned. Many methods are used for making this portion of the theater attractive. Excellent results are obtained when the illumination is accomplished by means of hanging fixtures as shown in Figure 100, by cove lighting; (see page 91) or by decorative portable lamps. In any case, the lamp bulbs are entirely concealed.

The intensity of light in the foyer should be much less than the bright street illumination, so that there is a gradation of illumination from the street to the dimly lighted auditorium.

Auditorium

The lighting of auditorium has probably been given more attention recently than that of any other portion of the theater. The indirect lighting system has been generally adopted. In the majority of cases hanging fixtures are used. Other methods can be employed in which the hanging central fixtures are entirely eliminated.

The newest means is that in which the lighting is from concealed sources located in side-wall boxes, brackets or coves. The special advantages where no ceiling fixtures are used are that the auditorium looks higher and larger, and no obstruction is offered to the projector or view. In the Parkside Theater, Chicago, a moving picture theater, a special system of lighting has been installed. (See page 109.) All lamps and reflectors are concealed from view. The auditorium is flooded with a strong, clear, comfortable illumination, coming from the side-wall box lighting units, which suggest themselves to the audience, not as lighting fixtures, but more as a decorative feature of the room.

Fig. 101. The Auditorium—California Theatre, San Francisco, California. Alfred H. Jacobs, Architect.

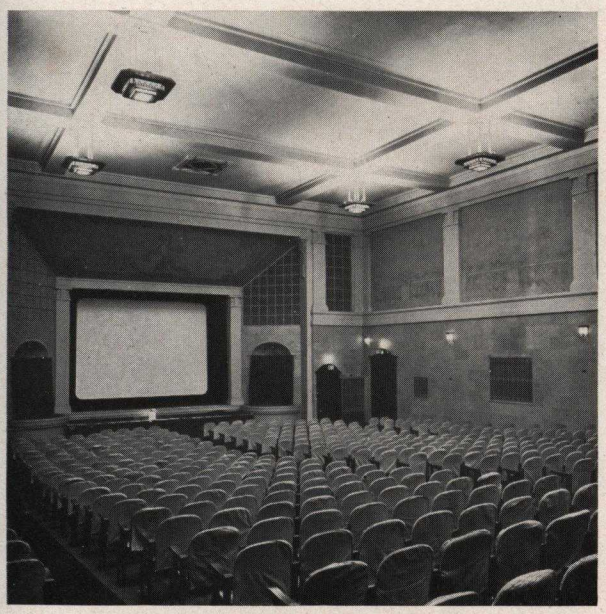


Fig. 102. Auditorium, De Luxe Theatre, Chicago, Ill. Using the X-ray Luminous Bowl Fixture

It is very desirable in the lighting of the auditorium to provide means whereby more than one intensity of illumination can be obtained. A dim or subdued light is desirable while the show is in progress, and a bright light is required for intermissions. The dim illumination while the pictures are being shown will assist the ushers to seat patrons and produce a more cheerful atmosphere than with the lights entirely turned off. The dim lighting can be arranged so that it will not interfere in any way with the clearness of the pictures on the screen. Dim and bright effects can be obtained either by means of dimmers used in the lighting circuits or by having the lamps in the fixtures wired on separate circuits and controlled from the operator's box.

At the Palace Theater, Milwaukee, Wisconsin, the lighting fixtures were considered as a part of the decorative scheme, carrying out the period of design which was used by the architect throughout the building, thus making the lighting arrangements in perfect harmony with the interior.

DE LUXE THEATRE, CHICAGO, ILL.

Auditorium

GENERAL NOTES:

Size of room—60 x 120 feet.
Floor area—7200 square feet.
Height of ceiling—30 feet.
Number of fixtures—12.
Lamps per fixture—six 100-watt.
Type of reflector—X-Ray No. EC 71.
Wattage consumed—1.0 watts per square foot.
Fixture suspended—36 inches from ceiling.

The large central fixture is twelve feet in diameter and eight feet deep from the top edge of the bowl to the bottom. The fixture is made of composition reinforced with steel lath and conceals twenty-seven specially designed reflectors for indirect lighting. Each reflector contains a 500-watt Mazda "C" lamp. All of the lamps are controlled from the switchboard and the circuits are divided up in such a way that several intensities of illumination may be had. With only a few lights burning, a sufficient illumination is received for janitor work, cleaning, etc.

Stage Lighting

New stage lighting methods have been devised, using X-Ray reflector equipment, which give an enormous saving of current over the old types of stage equipment that have been used for many years. A more complete description of this equipment is to be found on pages 148, 149 and 153.

Color Lighting Effects

Color lighting effects are frequently employed in the auditorium of the theatre, as well as in the entrance and foyer. Color effects are especially effective with the X-Ray Indirect lighting system, since the colored light is perfectly diffused throughout the room. In the auditorium of the California Theatre, illustrated in Fig. 101, each of the six large fixtures has a 500-watt lamp for general illumination and an additional 500-watt lamp for each of the three colors, red, blue and amber. The color combinations are obtained by using gelatine shields of the various colors above the reflector units in the bowl. Since all of the colors are operated on a dimmer system, any combination or gradation of color may be secured.

Fig. 103. View under balcony in auditorium, Palace Theatre, Milwaukee, Wis. Kirchhoff & Rose, Architects.

RESTAURANTS AND DINING ROOMS

Fig. 104. Grecian Marble Cafe, Blackstone hotel, Chicago, Ill. Marshall & Fox, Architects.

Above is illustrated the exquisite Grecian Marble Cafe of the Blackstone Hotel, Chicago. The ceiling of this room is divided into comparatively small and very heavy panels and is finished in ivory white. The fixtures consist of shallow bowls of plaster containing X-Ray Lighting equipment and supported by bronze chains.

A purely classical interior of this kind furnishes a very difficult problem with respect to the artificial lighting. The architects have been very successful in this case however. The indirect method has the advantage of removing the actual light sources from view and at the same time brings out the architectural features in their proper perspective and relation.

In addition to the room illustrated the grill room, the barber shop and kitchen, as well as the offices are equipped with the indirect lighting system.

Additional interesting methods for dining room lighting are given on pages 82, 93, 104 and 111.

BLACKSTONE HOTEL, CHICAGO, ILL.

Grecian Marble Cafe

GENERAL NOTES:

Size of room—47 x 50 feet.
Floor area—2350 square feet.
Height of ceiling—16 feet.
Number of fixtures—6.
Lamps per fixture—Twenty 60-watt.
Type of reflector—X-Ray No. E-60.
Wattage consumed—3.0 watts per square foot.
Fixtures suspended—48 inches.
Fixtures spaced—16 feet apart (approx.).

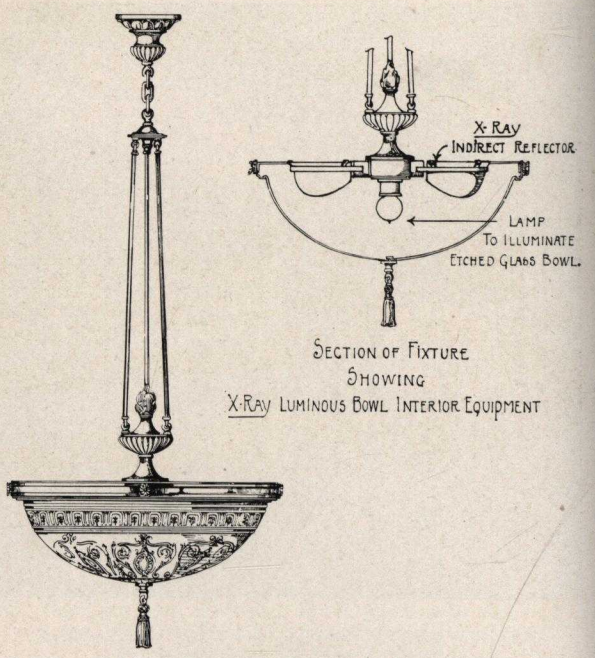


Fig. 105. Diagram and sectional view of fixture used in the tower room, Union League Club, Chicago, Ill.

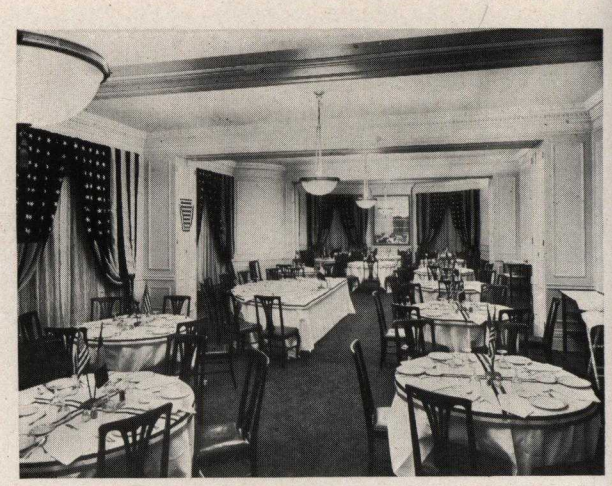


Fig. 106. Tower room, Union League Club, Chicago, Ill.

UNION LEAGUE CLUB, CHICAGO, ILL.

Tower Suite (Dining Room)

GENERAL NOTES:

Size of room—21 x 69 feet.
Floor area—1450 square feet.
Height of ceiling—12 feet.
Number of fixtures—4.
Lamps per fixture—Four 100-watt.
Type of reflector—X-Ray No. E-61.
Wattage consumed—1.1 watts per square foot.
Fixtures suspended—42 inches.
Fixtures spaced—15 to 18 feet apart.

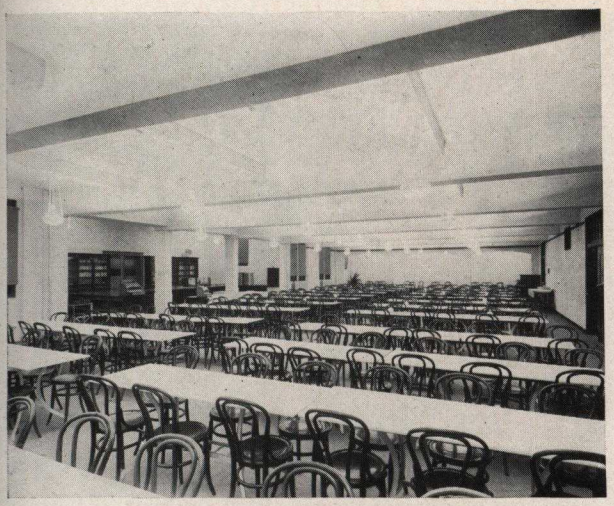


Fig. 107. Cafeteria, Lincoln high school, Lincoln, Neb. Burlinghof & Davis, Architects.

LINCOLN HIGH SCHOOL, LINCOLN, NEBR.

Cafeteria

GENERAL NOTES:

Size of room—35 x 82 feet.
Floor area—2870 square feet.
Height of ceiling—10 feet 6 inches.
Number of fixtures—24.
Lamps per fixture—1-100 watt.
Type of reflector—X-Ray No. EC-14.
Wattage consumed—.84 watts per square foot.
Fixtures suspended—30 inches from ceiling.
Fixtures spaced—about 12 feet apart.

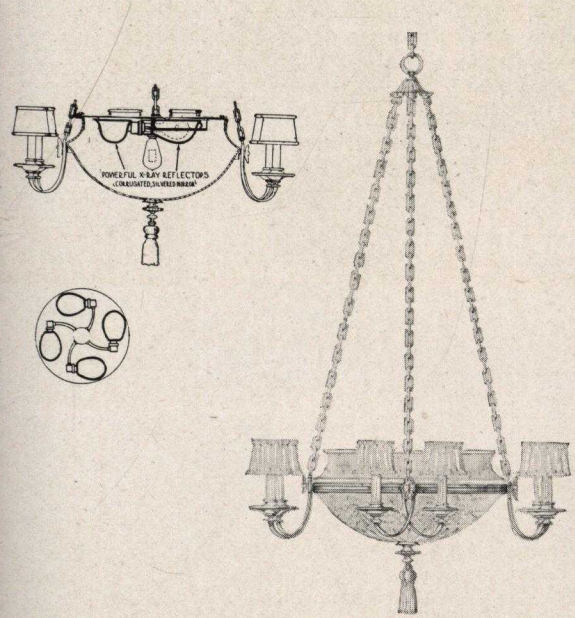


Fig. 108. Details of fixture in Dining Room of Union League Club, Chicago, Illinois.

Fig. 109. Dining room, Hotel Kramer, Stockholm, Sweden.

Union League Club

The main dining room or banquet hall of the Union League Club, of Chicago, is lighted by artistic glass bowl fixtures surrounded by dainty shaded candles. The details of this special fixture and its interior arrangements are shown below. One turn of the switch lights the glass bowl and the candles with a rich, mellow glow, which suffuses the room with a light sufficient for setting tables and for cleaning. At the dinner hour, the indirect illumination from the reflectors contained in the glass bowl is switched on.

Fig. 110. Dining room—Union League Club, Chicago, Ill.

Fig. 111. Large Ward—City Hospital, Indianapolis, Ind. Adolph Scherer, Architect. *See page 70 for data.*

HOSPITALS

It is essential and proper that the hospital be equipped with everything which will make it a greater comfort to the sick and a greater aid to the convalescent.

Correct illumination is tremendously important. There is no time at which our eyes are more likely to be injured than when the general condition is below normal, which is usually the case with patients confined in hospitals.

The bright glare of exposed lamps is detrimental to the progress of the patient. The illumination should have the softness and diffuse quality of day light. This can be obtained only by concealed lamps and with lighting by indirect methods.

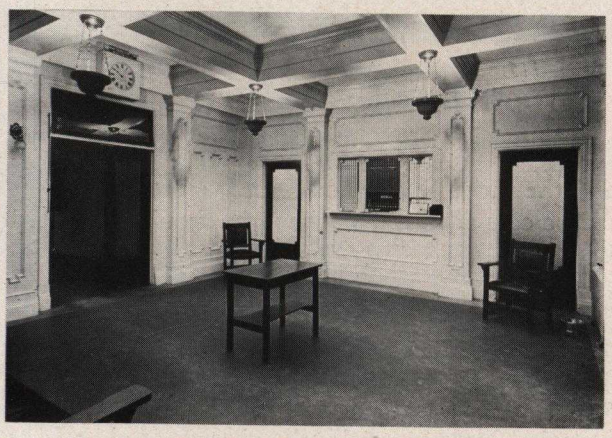


Fig. 112. Entrance lobby, University Hospital, Augusta, Ga. G. Lloyd Preacher, Architect. Meyer J. Sturm, Consulting Architect, Chicago, Ill.

Physicians realize the necessity of soft illumination in rooms where sick people are compelled to lie day after day. Long ago nurses learned that the bright glare of direct lights retarded the progress of their patients. By improvising shields which would protect the sick from the blinding rays of strong lamps, hospital attendants emphasize the necessity of indirect lighting in rooms where invalids are confined.

The advent of indirect lighting was welcomed heartily by hospital managements and today it is considered a most essential part of standard hospital equipment.

Wards

For large ward lighting, it has proved very satisfactory to control each fixture by an electrolier switch at the fixture or by a suitable switch on the wall arranged to give at least two intensities of illumination, and in some cases, three.

A low intensity to enable the nurses to wait on patients at night is desirable; second, a medium intensity for reading, etc.; and third, a high intensity for medical examination at the bed. The higher intensity is sometimes obtained by using wall plugs between the beds and localized reading lamps provided.

The private wards should be treated similarly to the bedroom of a residence, except that it is advisable to provide two intensities, low and medium, and baseboard receptacles for attaching portable direct lamps at the head of the bed.

In the wards and private rooms of some hospitals, ceiling fixtures have been entirely eliminated, the lighting being obtained from indirect lighting wall brackets above each bed.

In each of the large wards of the Indianapolis City Hospital six X-Ray Indirect lighting fixtures are used with six 60-watt Mazda Lamps in each, thus furnishing the entire illumination for a ward measuring 24 feet wide and 30 feet long, with a ceiling height of 13 feet. The fixtures are controlled by a six-point wall switch which provides six degrees of illumination.

The method of obtaining two or three intensities of light in the wards is most frequently accomplished

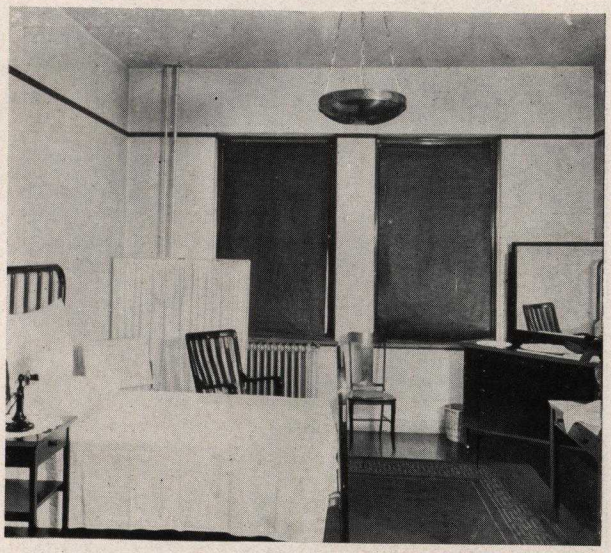


Fig. 113. Private ward, Milwaukee Hospital, Milwaukee, Wis. Meyer J. Sturm, Architect, Chicago, Ill.

MILWAUKEE HOSPITAL, MILWAUKEE, WIS.

Private Ward

GENERAL NOTES:

Size of room—14 feet 6 inches x 16 feet 6 inches.
Floor area—239 square feet.
Height of ceiling—11 feet 6 inches.
Number of fixtures—1.
Lamps per fixture—Four 40-watt.
Type of reflector—X-Ray No. E-60.
Wattage consumed—.67 watts per square foot.
Fixtures suspended—48 inches.

INDIANAPOLIS CITY HOSPITAL
INDIANAPOLIS, IND.
Large Ward (*See page 68*)

GENERAL NOTES:

Size of room—24 x 90 feet.
Floor area—2160 square feet.
Height of ceiling—13 feet.
Number of fixtures—6.
Lamps per fixture—Six 60-watt.
Type of reflector—X-Ray No. E-60.
Wattage consumed—1.0 watt per square foot.
Fixtures suspended—48 inches.
Fixtures spaced—15 feet apart.

by means of fixtures containing several reflectors or multi-unit fixtures as they are called. For instance, for a fixture containing four 60-watt lamps and controlled by an electrolier switch, one of the 60-watt lamps may be used for the dim lighting, two lamps for the medium lighting, and all four lamps for the bright lighting.

Offices

The offices require a thoroughly diffuse illumination, about the same as provided for ordinary commercial office lighting.

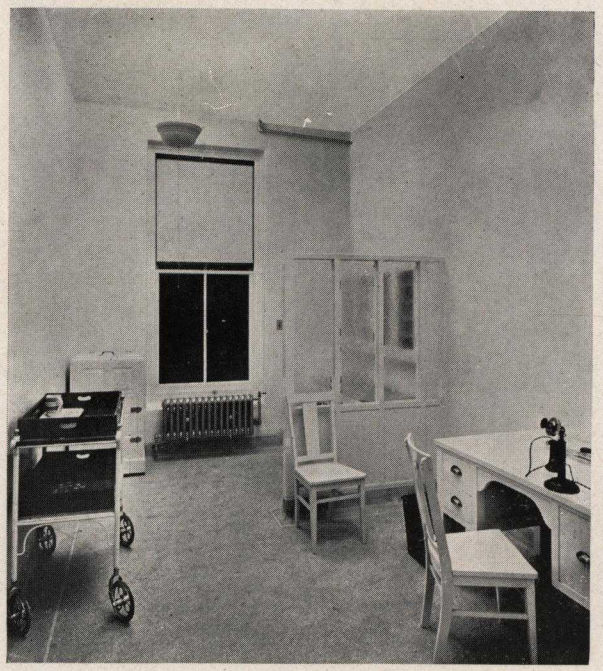


Fig. 114. Nurses' duty room, Harper Hospital, Detroit, Mich. Malcolmson & Higginbotham, Architects.

Diet Kitchens and Duty Rooms

Very little food is prepared in a diet kitchen after dark, and unless the nurses use this room as a record room, it should be treated as a kitchen.

In many instances, however, the diet kitchen

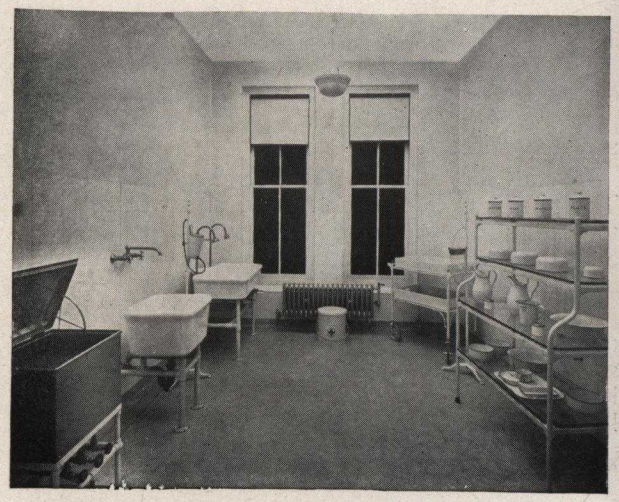


Fig. 115. Service room, Harper Hospital, Detroit, Mich. Malcolmson & Higginbotham, Architects.

contains a gas stove at one end of the room, with the usual kitchen implements, while at the other end the nurse has her desk and records.

In a case of this kind, the room should be treated as an office, not as a diet kitchen. Treated as an office the indirect lighting system will of course be found the most desirable.

Surgical Dressing Rooms

Attention is called to the illustration of the Surgical Dressing Room of the Harper Hospital, Detroit. Note especially the absence of glare from the glass shelves on the dressing tables, also the detail with which the various accessories stand out in the room.

HARPER HOSPITAL, DETROIT, MICH.
Nurses' Duty Room

GENERAL NOTES:

Size of room—10 x 16 feet.
Floor area—160 square feet.
Height of ceiling—12 feet.
Number of fixtures—2.
Lamps per fixture—Two 40-watt.
Type of reflector—X-Ray No. E-60.
Wattage consumed—1.0 watts per square foot.
Fixtures suspended—18 inches.
Fixtures spaced—8 feet apart.

HARPER HOSPITAL, DETROIT, MICH.
Surgical Dressing Room

GENERAL NOTES:

Size of room—12 x 16 feet.
Floor area—192 square feet.
Height of ceiling—12 feet.
Number of fixtures—2.
Lamps per fixture—Two 60-watt.
Type of reflector—X-Ray No. E-60.
Wattage consumed—1.25 watts per square foot.
Fixtures suspended—24 inches.
Fixtures spaced—8 feet apart.

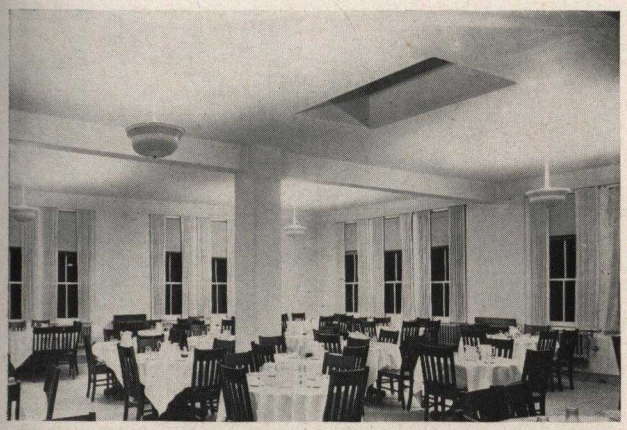


Fig. 116. Staff dining room, Harper Hospital, Detroit, Mich. Malcolmson & Higginbotham, Architects.

HARPER HOSPITAL, DETROIT, MICH.

Staff Dining Room

GENERAL NOTES:

Size of room—38 x 48 feet.
Floor area—1824 square feet.
Height of ceiling—12 feet.
Number of fixtures—6.
Lamps per fixture—Four 60-watt.
Type of reflector—X-Ray E-60.
Wattage consumed—.79 watts per square foot.
Fixtures suspended—30 inches.
Fixtures spaced—16 to 19 feet apart.

Fig. 117. Corridor, Harper Hospital, Detroit, Mich. Malcolmson & Higginbotham, Architects.

Corridors

The corridor requires only a low intensity of illumination, and should always be treated with the indirect lighting.

In going to and from the operating rooms and wards and private rooms, the patients should not be subjected to the view of exposed light sources in the corridors.

Fig. 118. Children's room, City Hospital, Indianapolis, Ind. Adolph Scherrer, Architect.

HARPER HOSPITAL, DETROIT, MICH.

Corridor

GENERAL NOTES:

Size of room—192 feet long, 8 feet wide.
Floor area—1536 square feet.
Height of ceiling—11 feet.
Number of fixtures—9.
Lamps per fixture—Two 40-watt.
Type of reflector—X-Ray No. E-60.
Wattage consumed—.47 watt per square foot.
Fixtures suspended—24 inches.
Fixtures spaced—21 feet apart.

Fixtures

Hospital fixtures should be plain with pleasing lines, built so as to insure ease of maintenance. The fixtures are preferably finished in a washable white or cream.

A small added expenditure for ornamenting the lighting unit of the wards, private rooms, lobby, corridors, reception room, and offices of the hospital is worth while. If the appropriation for the lighting

fixtures is limited, this increase, although very slight, may be offset by using the plainest lighting fixtures for the remainder of the building.

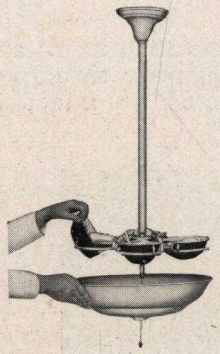


Fig. 119. Method of removing bowl and reflectors for cleaning hospital fixtures.

Fig. 120. Hospital fixture, showing method of cleaning.

Fig. 121. Glass cover sometimes used over hospital lighting fixtures.

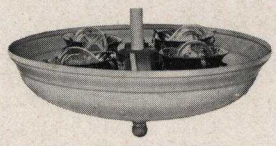


Fig. 122. View showing X-Ray reflector equipment inside of hospital fixture.

HOSPITAL OPERATING ROOMS

In operating rooms where a very high intensity of light is required, the lighting equipment should be designed so that the surgeon may work without the possibility of standing in his own light; in other words, to preclude the possibility of shadows. In the design of fixtures for operating rooms, it is necessary that the fixtures be so arranged as to protect the patient from the possibility of dust falling into the wounds from the fixture, and consequent infection, and also to protect both the patient and the operator from the heat of the lighting unit. With installations having overhead direct lighting units, the glare from the reflectors into the surgeon's eyes may, in case he looks up from the field of operation, blind him to such an extent that he must necessarily stop work long enough to allow the pupil of the eye to adjust itself to the amount of light thrown on the working plane.

Indirect lighting in operating rooms is particularly effective when properly arranged, but if this manner of illumination is to be adopted, it must be carefully calculated to produce practically shadowless illumination of high intensity on the operating table.

If the best illumination for operations is daylight, then, the best artificial method of illumination is indirect. Where the operating room has a large enough ceiling area to utilize the indirect method of illumination, this method should be used in preference to direct lighting. The light, diffuse shadows cast by the X-Ray Indirect System will enable the surgeon to see to better advantage without the use of the exploratory lamp than with any other system.

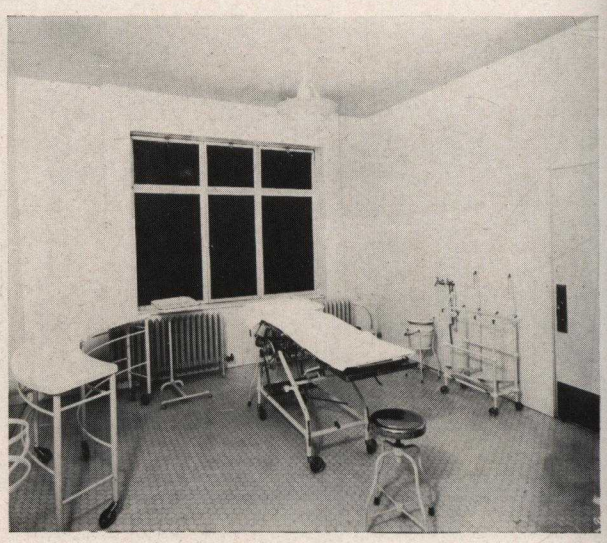


Fig. 123. Operating room, St. Joseph's Hospital, Kansas City, Mo. Wright & Wright, Architects.

For a description of the use of direct lighting in Hospital Operating rooms see page 146.

ST. JOSEPH'S HOSPITAL, KANSAS CITY, MO.

Operating Room

GENERAL NOTES:

Size of room—15 x 15 feet.
Floor area—225 square feet.
Height of ceiling—10 feet 8 inches.
Number of fixtures—1.
Lamps per fixture—One 500-watt.
Type of reflector—X-Ray No. EC-345.
Wattage consumed—2.22 watts per square foot.
Fixtures suspended—30 inches from ceiling.

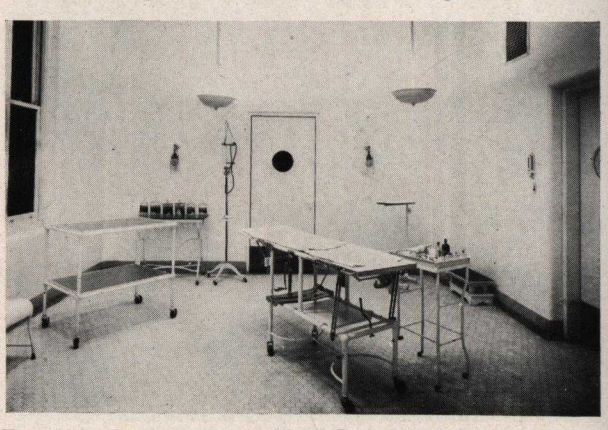


Fig. 124. Operating room, Hotel Dieu hospital, New Orleans, La. Paul Andry, Architect.

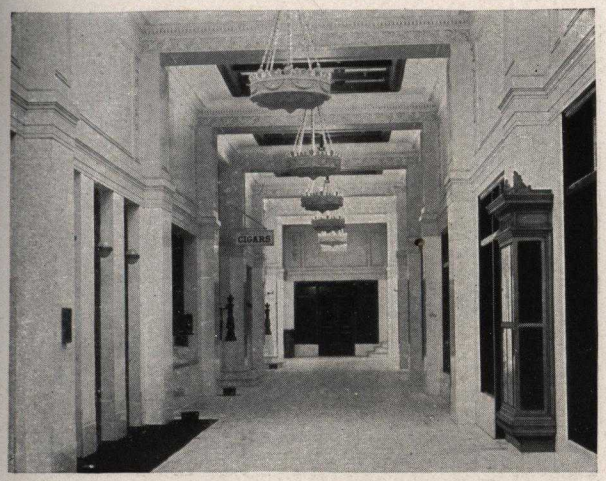


Fig. 125. Elevator lobby of Karpen Building, Chicago, Ill. Marshall & Fox, Architects.

PUBLIC SPACES

Public spaces include a great variety of interiors, which may or may not fall into one of the classifications given on the previous pages. They comprise elevator lobbies, vestibules, waiting rooms, main corridors of office buildings, court houses, city halls, municipal buildings, art galleries, railway stations, etc. These spaces require a general illumination with fixtures which are usually decorative in character.

Various means for lighting these spaces have been used. The recent practice with hanging fixtures is shown in the figures on this page. On page 145 is illustrated the use of a skylight for the supplying of daylight as well as artificial illumination. In the atrium of the Municipal Building of Hartford, Connecticut, the illumination at night from the skylight is practically a daylight effect.

An example of the use of cove lighting for public spaces is shown on page 91, the vestibule of the Wisconsin Telephone Building, Milwaukee, Wisconsin. Care must be taken in installations of this kind in the selection and the placing of units, so as to avoid a "scalloped" effect on the walls and ceiling. Best cove lighting results are obtained by the use of specially designed non-symmetrical reflectors rather than with reflectors not originally intended for this particular application.

KARPEN BUILDING, CHICAGO, ILL.

Corridor

GENERAL NOTES:

Size of room—16 x 200 feet.
Floor area—3200 square feet.
Height of ceiling—18 feet.
Number of fixtures—9.
Lamps per fixture—Six 100-watt.
Type of reflector—X-Ray No. EC-15.
Wattage consumed—1.7 watts per square foot.
Fixtures suspended—54 inches.
Fixtures spaced—22 feet apart.

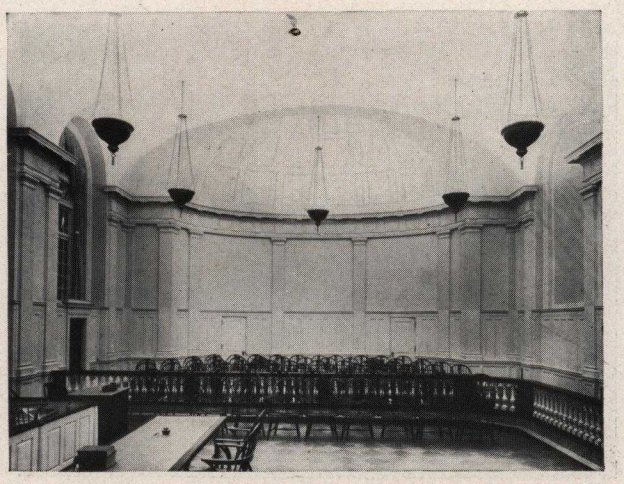


Fig. 126. Court room, City Hall, Hartford, Conn. Davis & Brooks, Architects.

CHICAGO, INDIANAPOLIS & LOUISVILLE R. R.

HAMMOND, IND.

Waiting Room

GENERAL NOTES:

Size of room—55 x 20 feet.
Floor area—1,100 square feet.
Height of ceiling—18 feet.
Number of fixtures—3.
Lamps per fixture—Five 100-watt.
Type of reflector—X-Ray No. EC- 15.
Wattage consumed—1.36 watts per square foot.
Fixtures suspended—60 inches.

Fig. 127. Station waiting room, Chicago, Indianapolis & Louisville R. R., Hammond, Ind. Marshall & Fox, Architects, Chicago, Ill.

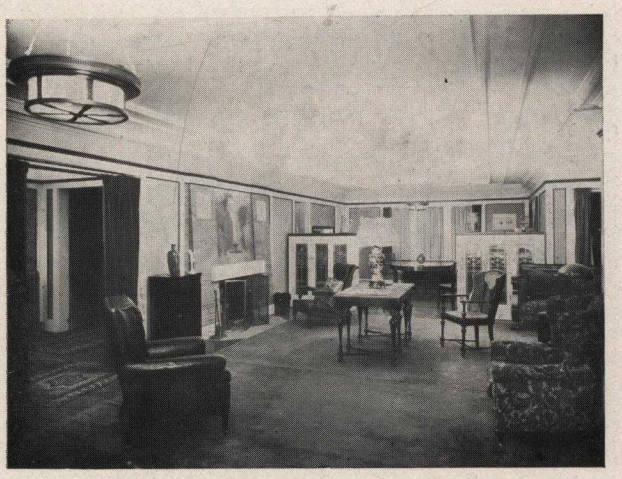


Fig. 128. Living room. Residence of Mr. F. D. Butler, River Forest, Ill. Spencer & Powers, Architects, Chicago, Ill.

Fig. 129. Music room. Residence of Mr. A. J. Lindemann, Milwaukee, Wis. Fitzhugh Scott, Architect.

RESIDENCES

The home, of all classes of interiors, offers the most interesting studies in lighting methods and effects. From the hygienic aspect alone, considering that the eyesight is the faculty which most often and most markedly declines with advancing years, the illumination of the home should receive very serious and careful attention. Here, to eyes that are tired, softly diffused and restful illumination is most gratifying. From the decorative aspect, the lighting of the home gives the greatest opportunity for the exercising of ingenuity in producing unusual effects, and for the working out of the individual tastes of the householder.

The room can be lighted as a whole with all points equally illuminated, or one corner may be comparatively bright with a gradation of intensity to the farther corners, producing a more cozy effect. Ceiling fixtures as commonly used may be entirely eliminated in favor of portable lamps, side wall fixtures, or cove lighting fixtures.

Living Room

In the living room, the illumination must combine the requirements of beauty and utility. It must have practical lighting qualities and elasticity.

RESIDENCE A. J. LINDEMANN

Music Room

GENERAL NOTES:

Size of room—20 x 26 feet.
Floor area—520 square feet.
Height of ceiling—10 feet 6 inches.
Number of fixtures—2.
Lamps per fixture—Three 100-watt.
Type of reflector—X-Ray E-61.
Wattage consumed—1.15 watts per square foot.
Fixtures suspended—36 inches.
Fixtures spaced—13 feet apart.

The example given by the living room in Figure 128 shows how novel effects can be produced by unique methods of placing the lighting units. The lighting fixtures consist of two X-Ray luminous bowl units in the center of the ceiling, two urn lights, two ornamental brackets, one indirect lighting bracket back of the organ, one indirect lighting portable lamp, and one ornamental portable lamp. With these various units three color lighting effects can be obtained in a room.

A very light green color effect is produced from a light green gauze placed over the urn light at location No. 2 and from the indirect bracket reflector placed behind the organ in location No. 4,

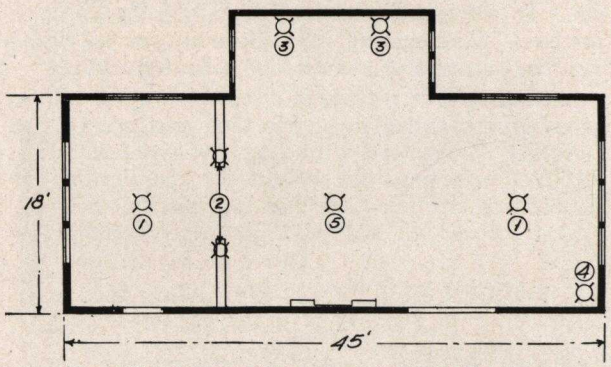


Fig. 130. Plan of living room shown in Fig. 128.

and also from the green dragon table lamp in location No. 5. The urn lights contain X-Ray reflectors No. E-15 and the bracket over the organ reflector No. E-65.

A warm amber color effect is obtained from the luminous bowl fixtures with the auxiliary light only

Fig. 131. Dining room. Residence of Mr. Augustus D. Curtis Chicago, Ill.

burning in the bowl at location No. 1, and from the auxiliary light behind the table lamp shade at No. 5 and from two brackets at location No. 3. The colors on the silk shades at location No. 3 and location No. 5 harmonize with the color of the glass at No. 1.

White light is obtained by using indirect fixtures at locations No. 1 and 5. The fixtures at

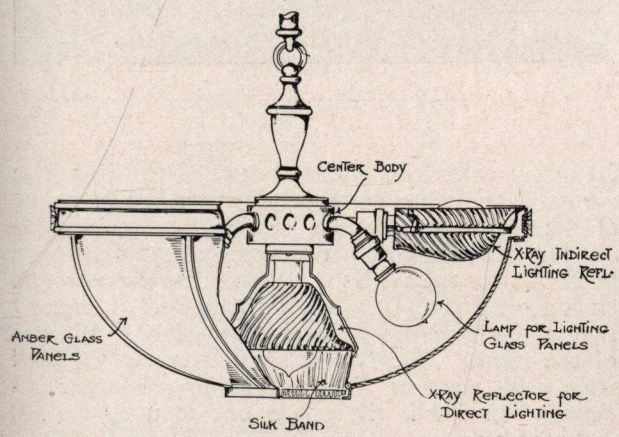


Fig. 132. Section of special dining room fixture.

RESIDENCE AUGUSTUS D. CURTIS

Dining Room

GENERAL NOTES:

Size of room—16 feet x 19 feet 6 inches.
Floor area—312 square feet.
Height of ceiling—9 feet 6 inches.
Number of fixtures—1.
Lamps per fixture—Four 60-watt.
Type of reflector—X-Ray No. E-60.
Wattage consumed—.77 watt per square foot.
Fixtures suspended—27 inches.

No. 1 are on three way switches, thereby giving several intensities to the white light.

The use of the portable lamp in the home is illustrated on page 102 and details of the illumination of a private library by means of an X-Ray luminous bowl type fixture are given on page 84.

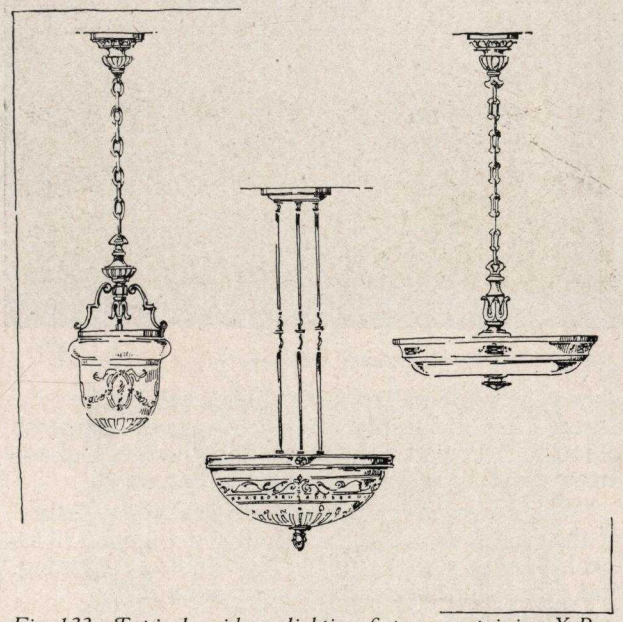


Fig. 133. Typical residence lighting fixtures containing X-Ray reflectors.

Dining Room

Two things are of importance in lighting the dining room—the general illumination and the lighting of the table. An X-Ray indirect lighting fixture placed, as shown in the illustrations, just

Fig. 134. Dining room and living room in residence showing use of luminous bowl fixture.

Fig. 135. Bed room with X-Ray luminous bowl fixture.

above the table will in most cases combine the two effects most admirably, since it produces a general diffusion throughout the room, and gives its highest intensity of light just beneath the fixture.

When greater refinements are desired, a fixture of the type shown diagramatically in Figure 132 is ideal. In this unit the X-Ray indirect lighting and direct lighting features are combined.

The direct lighting reflector casts a strong downward light through an opening in the bottom of the fixture, cutting off sharply at the edges of the table, giving a sparkle to the glass and silverware. This direct light is cleverly shaded from the eyes of those seated at the table. Reflectors at the top of the fixture, with lamps burning in a horizontal position furnish the general indirect lighting for the room. The switching of the fixture is such that several intensities of light can be had. The panels of the bowl of the fixture are amber glass, and the light that filters through upon the faces of those around the table has an amber tone, and gives a most pleasing effect. Color lighting effects for special occasions, such as Thanksgiving, Christmas, Hallowe'en, can be produced by color filters placed in holders that have been provided over each X-Ray indirect lighting reflector.

RESIDENCE

Bed Room

GENERAL NOTES:

Size of room—14 x 16 feet.
Floor area—224 square feet.
Height of ceiling—9 feet.
Number of fixtures—1.
Lamps per fixture—One 75-watt.
Type of reflector—X-Ray No. EC-12.
Wattage consumed—.34 watt per square foot.
Fixture suspended—20 inches.

Bed Rooms

The luminous bowl indirect fixture gives effective results in the bed room. Just enough light penetrates the outer decorative glass bowl to produce a pleasing effect. Bowls in white with traceries of roses or festoons of small flowers are most appropriate. A fixture containing one lamp is usually sufficient for the bed room.

Kitchen and Bath Room

The utilitarian features of these rooms make it desirable to install a plain fixture of simple design.

Fig. 136. Kitchen in residence.

In many cases the entire fixture is finished in a washable white to correspond with the enameling of the woodwork of the room, and to maintain a sanitary appearance. Sometimes direct lighting is preferred for the kitchen. In this case the reflectors shown on page 119 when attached to a canopy fitting at the ceiling giving a strong light in all parts of the room. The No. 535 reflector can be used with a 60 watt or 75 watt lamp, while the reflector No. 570 is the proper one to use for a 100 watt lamp.

RESIDENCE

Kitchen

GENERAL NOTES:

Size of room—10 x 16 feet.
Floor area—160 square feet.
Height of ceiling—10 feet 6 inches.
Number of fixtures—1.
Lamps per fixture—One 200-watt.
Type of reflector—X-Ray No. EC-12.
Wattage consumed—1.25 watts per square foot.
Fixtures suspended—30 inches.

Fig. 137. Porch lighted by indirect illumination.

RESIDENCE

Porch

GENERAL NOTES:

Size of room—8 x 32 feet.
Floor area—256 square feet.
Height of ceiling—9½ feet.
Number of fixtures—1.
Lamps per fixture—One 75-watt.
Type of reflector—X-Ray No. EC-12.
Wattage consumed—.29 watt per square foot.
Fixture suspended—20 inches.

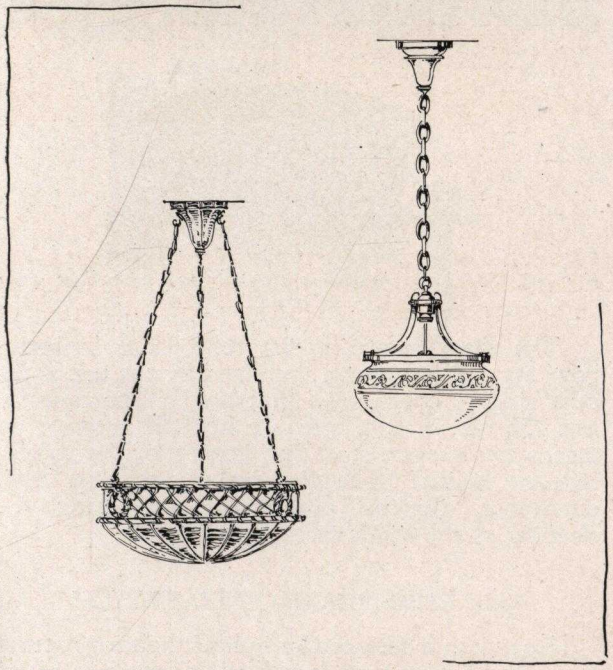


Fig. 138. Typical fixtures for porches and sun rooms, containing X-Ray reflectors.

Porch and Sun Room

The flexibility of indirect lighting makes it an ideal method for porch and sun room. Any degree of illumination from a moonlight glow to a bright lighting, equal to that for any room in the home, can be obtained by varying the size of the lamp in the fixture or by a switching arrangement that turns on successively the lamps in a multi-unit fixture.

A ceiling fixture of wicker, silk, glass or metal can be used, or the lighting effect may be secured with a Curtis Portable lamp or an indirect side wall bracket fixture. The idea of a hanging fern or flower basket is easily combined with that of the lighting fixture, as shown in Fig. 137.

The illumination requirements in foot candles and the watts per square foot for the various rooms in the home are given in table No. 2 on page 34. For such rooms as sewing room, billiard room and kitchen, a more intense illumination is necessary than for the living rooms of the home. In general, it is a good plan to provide wiring sufficient for at least a watt per square foot for every room.

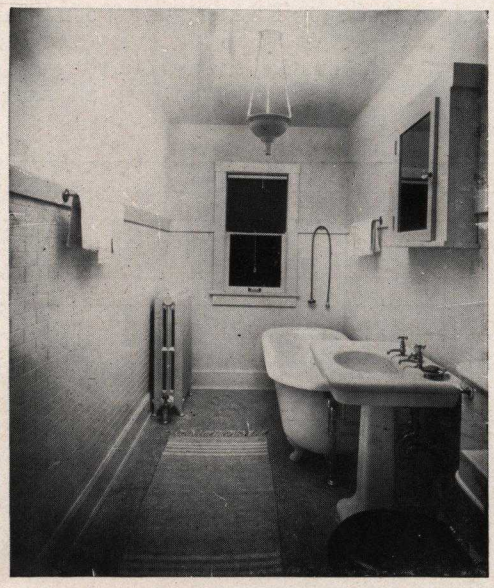


Fig. 139. Bath room.

The requirements for wattage consumption vary from .25 for hallways up to 1.6 for sewing room. Reference should be made to page 84, where further detailed information for the lighting of the home is given.

RESIDENCE

Bathroom

GENERAL NOTES:

Size of room—7½ x 10 feet.
Floor Area—75 square feet.
Height of ceiling—9 feet.
Number of fixtures—1.
Lamps per fixture—1 60-watt.
Type of reflector—X-Ray No. EC-15.
Wattage consumed—.8 watts per square foot.
Fixture Suspended—20 inches.

MAINTENANCE

Many lighting installations which were at first carefully selected and properly installed are after a time condemned. Complaint of insufficient illumination is often attributed to the type of system in use, while the real cause—the lack of proper maintenance—is lost sight of. Service is the basis on which any lighting system must be judged, and maintenance is the factor upon which continued satisfactory service depends. There are three important factors which cause depreciation and result in a loss of illumination intensity.

(A) Dust collection on the lamp and reflector.

(B) The soiling of ceiling and walls.

(C) Ageing of lamps.

It has been demonstrated by actual tests on lighting installations, that they show a decrease of lighting efficiency of approximately 10% a month due to the accumulation of dirt and dust. This fact is shown graphically in Figure 140. If lamps and reflectors are cleaned regularly every two months the average illumination throughout the year would be over 80% of that received with all equipment clean.

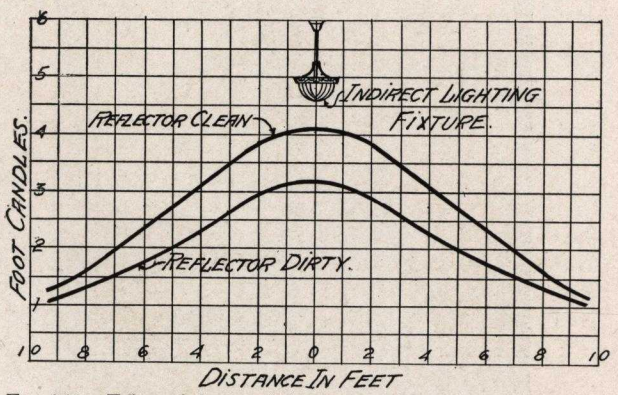


Fig. 140. Effect of dust and dirt accumulation on the efficiency of a lighting system.

A regular schedule of cleaning should be adopted and whenever possible maintenance should be in charge of a competent individual identified with the electrical department rather than under the janitor service.

Incandescent lamps should be replaced when they become black from long use. The efficiency of an incandescent lamp drops rapidly after burning 1,000 hours. The lamp manufacturers state that incandescent lamps are designed to operate in such a manner that at the end of their rated life the candle power is approximately 80% of the initial.

In making a study of economics of office building lighting, Mr. S. G. Hibben recently found that the cost of cleaning lamps and for lamp renewals is a very small part of the total operating cost of the building.

The diagram below shows the relationship. The cost of lamp renewals is about 1% of the total operating cost, while the cost for cleaning lighting equipment is less than 4%. It will, therefore, be seen that at a comparatively slight expense the lighting installation may be kept up close to its original efficiency.

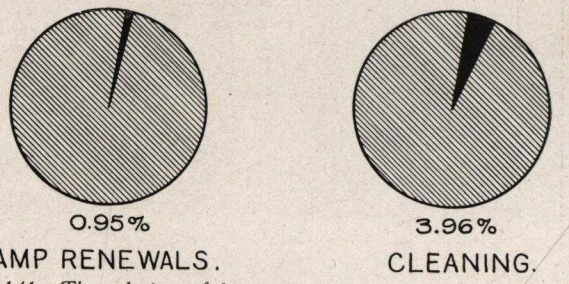


Fig. 141. The relation of lamp renewals and cleaning to the total cost of operating an office building.

DUST COVER FOR LUMINOUS BOWL

One of the popular objections to fixtures of the luminous type employing glass bowls is their tendency to collect dust and dirt which, when the bowl is lighted, is clearly visible and hence mars the general appearance of the fixture.

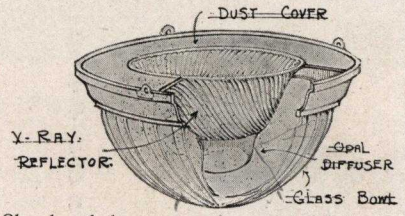


Fig. 142. Sketch of luminous fixture bowl with dust cover in place.

The maintenance of fixtures of the luminous bowl type is very much simplified by the use of the dust ring or cover here illustrated. The reflector and diffuser in this case are held in position by means of the spun steel disc instead of the regular reflector holder. The disc makes the glass bowl dust-proof, thereby practically eliminating the cleaning of the inside of the glass bowl.

THE ELECTROLIER PULL SWITCH

This switch is designed for indirect lighting fixtures where there is no wall switch in the room or where it is desired to turn on the lamps in the bowl one at a time, especially in connection with residence and hospital lighting. The switch is inside of the bowl and is operated by pulling a cord hanging from the under side of the bowl as illustrated.

Only fixtures containing two or more lamps can be equipped with this type of switch.

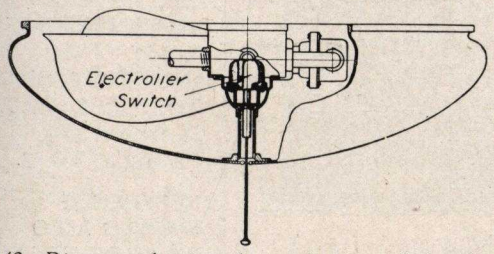


Fig. 143. Diagram showing the mechanism of the electrolier pull switch.

LOWERING DEVICE FOR LARGE FIXTURES

When fixtures are hung from high ceilings where access with a ladder for cleaning is impractical, arrangements must be made for lowering the fixtures.

The method illustrated in Figures 145 and 146 is recommended for cases of this kind. It consists of a safety worm gear device. With this winch the load cannot drop or run down.

The arrangement shown is for use with large sized fixtures where the load is to remain suspended. For extra large or heavy fixtures, the lowering device should be relieved of the strain of the weight of the fixture.

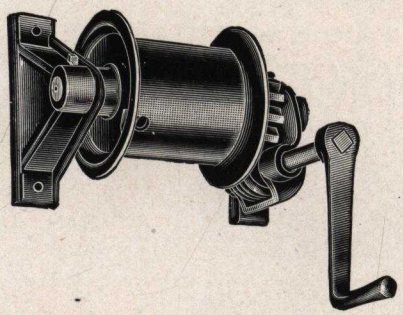


Fig. 144. Worm gear windlass used for lowering and raising lighting fixtures installed on high ceilings.

The device illustrated in Figure 144 is a standard hand power winch made in two sizes, one having lifting capacity of 500 pounds and the other a capacity of 750 pounds.

Other methods are shown in pages 152 and 158. In the one case the lowering device automatically makes and breaks the electrical circuit when the fixture is raised or lowered. The whole operation is accomplished from the ground or floor by merely turning a crank situated near the base of the arches forming the roof structure. All wiring and cables are cleverly concealed in the steel work.

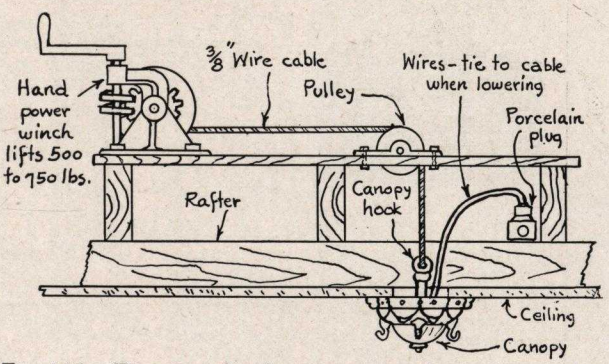


Fig. 145. Elevation of safety worm gear device for lowering lighting fixture.

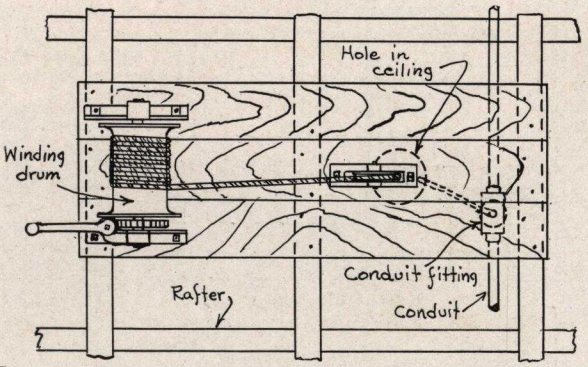
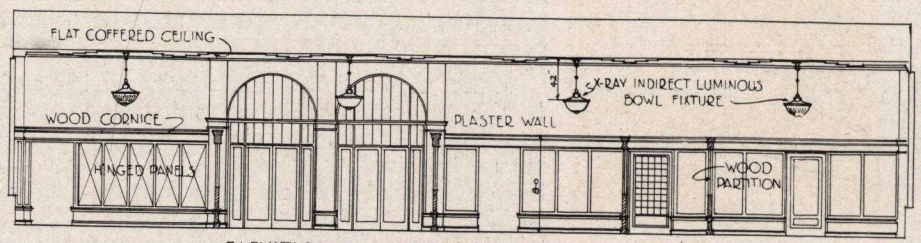
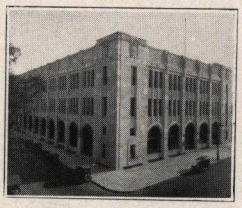


Fig. 146. Plan of safety worm gear device for lowering lighting fixtures.

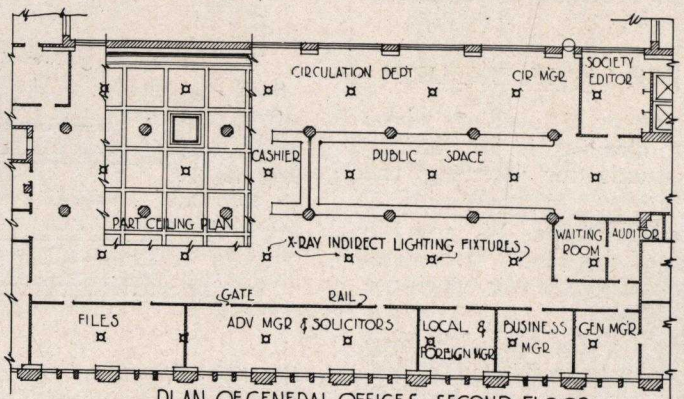
PUBLIC BUILDINGS OF DISTINCTION ARE FITTED WITH X-RAY LIGHTING



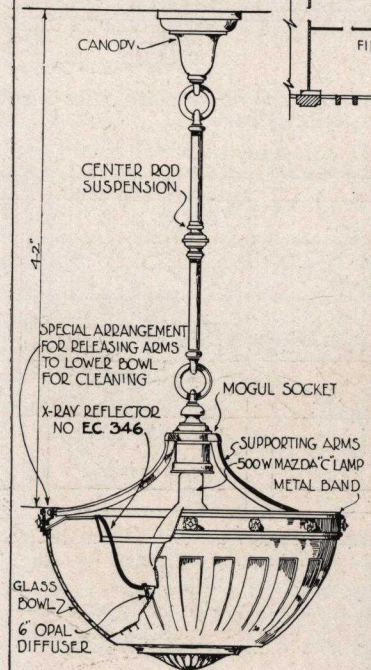
ELEVATION OF NORTH WALL OF GENERAL OFFICES



DIGNIFIED & IMPOSING HOME OF THE DETROIT NEWS



PLAN OF GENERAL OFFICES · SECOND FLOOR

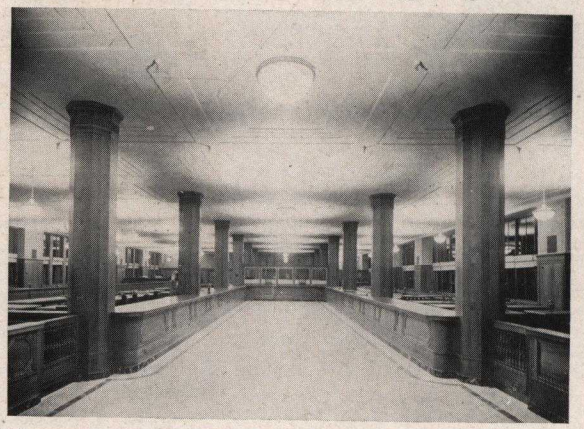


THE LUMINOUS BOWL LIGHTING FIXTURE

A SPECIAL DESIGN BY OUR FIXTURE DEPT.

GENERAL NOTES

GENERAL OFFICE 80'-0" X 153'-0" - CEILING HEIGHT 14'-4"
AREA ILLUMINATED 12100 SQ FT
28-X-RAY LUMINOUS BOWL INDIRECT LIGHTING FIXTURES NO 1994 X INSTALLED
EACH FIXTURE CONTAINS X-RAY REFLECTOR NO EC 346 WITH 500 W MAZDA "C" LAMP-LENGTH OF SUSPENSION 42" TOP OF BOWL TO CEILING
TOTAL WATTAGE 14000 WATTS-WATTAGE PER SQ FT 1.15



GENERAL OFFICE OF THE DETROIT NEWS BUILDING – DETROIT MICH.

ALBERT KAHN - ARCHITECT — DETROIT - MICH — ERNEST WILBY - ASSOCIATE

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

OFFICES

THE APPLICATION OF X-RAY INDIRECT LIGHTING TO OFFICE SPACES IS GIVEN ON PAGES 39 TO 43.

REFERENCE SHOULD ALSO BE MADE TO PAGES 97, 147 AND 207.

CLUBS

A DISCUSSION OF CLUB LIGHTING IS GIVEN ON PAGES 50 AND 51.

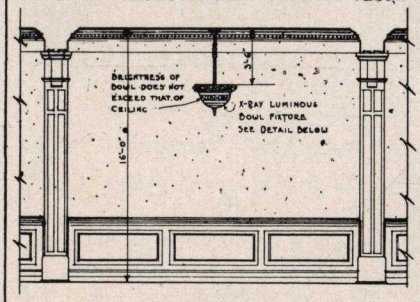
REFERENCE SHOULD ALSO BE MADE TO THE EXAMPLES ON PAGES 66, 110 AND 150.

UNION LEAGUE CLUB — LOUNGE —

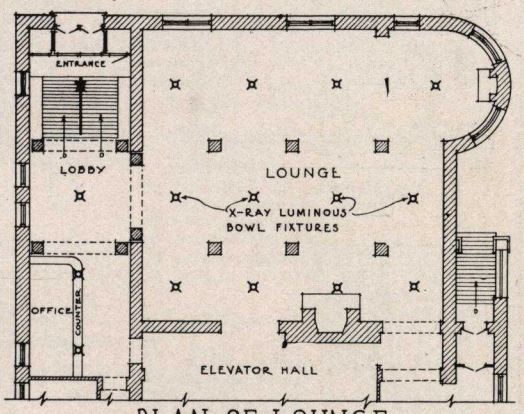
WM B MUNDIE ARCHT – CHAIRMAN OF ART COMMITTEE

CHICAGO —— ILLINOIS

NIGHT PICTURE OF LOUNGE WITH OLD DIRECT LIGHTING SYSTEM NOTE TRANSFORMATION IN VIEW BELOW



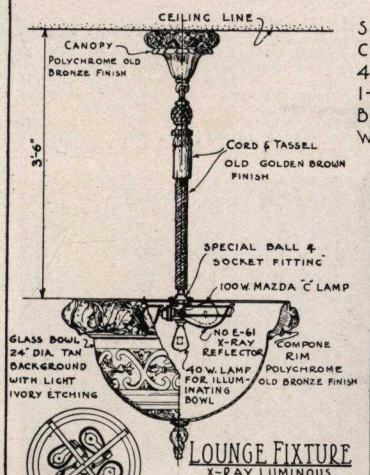
SECTION OF TYPICAL BAY



PLAN OF LOUNGE

INSTALLATION DATA

SIZE OF TYPICAL BAY 20'-0" X 18'-0" FLOOR AREA 3540 SQ.FT
CEILING HEIGHT 16'-0" ONE (1) FIXTURE PER BAY (SEE DETAIL)
4-100 WATT MAZDA "C" LAMPS IN **E-61** X-RAY REFLECTORS
1-40 WATT LAMP PER FIXTURE FOR LIGHTING GLASS BOWL. TOP OF REFLECTORS TO CEILING 3'-6"
WATTAGE PER SQ FT 1.10



LOUNGE FIXTURE
X-RAY LUMINOUS BOWL TYPE

PLAN OF FIXTURE SHOWING ARRANGEMENT OF REFLECTORS INSIDE OF BOWL

DESIGNED & EXECUTED BY FIXTURE DE'PT. NATIONAL X-RAY REFL. CO.

NIGHT VIEW OF LOUNGE AFTER X-RAY LUMINOUS BOWL FIXTURES WERE INSTALLED

THE NATIONAL X-RAY REFLECTOR © CHICAGO & NEW YORK.

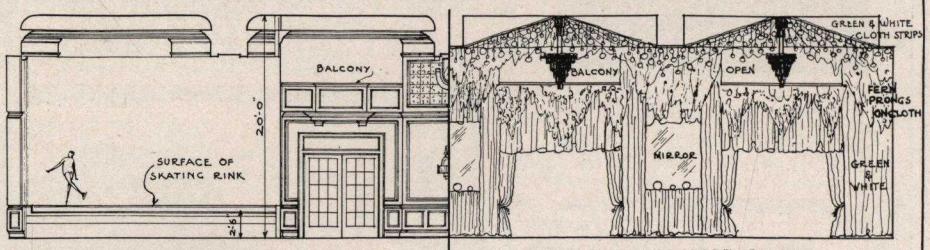
A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

ALEXANDRIA HOTEL

—LOS ANGELES CAL.—

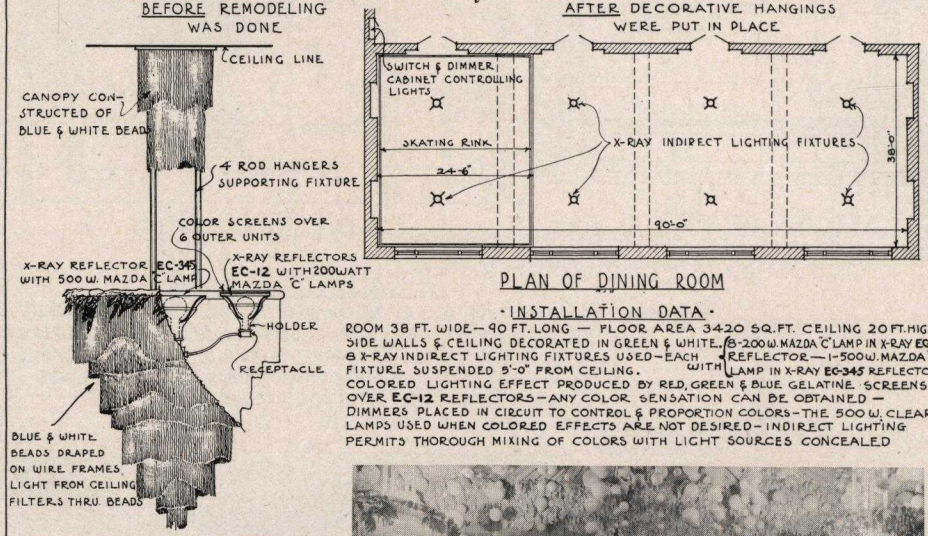
COLOR LIGHTING EFFECTS IN DINING ROOM

EDWIN BERGSTROM —— ARCHITECT



LONGITUDINAL SECTION OF ROOM
BEFORE REMODELING WAS DONE

LONGITUDINAL SECTION OF ROOM
AFTER DECORATIVE HANGINGS WERE PUT IN PLACE

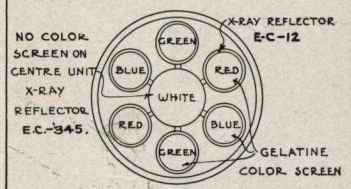


DETAIL OF FIXTURE

PLAN OF DINING ROOM

INSTALLATION DATA

ROOM 38 FT. WIDE — 90 FT. LONG — FLOOR AREA 3420 SQ. FT. CEILING 20 FT. HIGH SIDE WALLS & CEILING DECORATED IN GREEN & WHITE. 8 X-RAY INDIRECT LIGHTING FIXTURES USED — EACH FIXTURE SUSPENDED 5'-0" FROM CEILING. WITH 8-200 W. MAZDA 'C' LAMP IN X-RAY EC-12 REFLECTOR — 1-500 W. MAZDA 'C' LAMP IN X-RAY EC-345 REFLECTOR COLORED LIGHTING EFFECT PRODUCED BY RED, GREEN & BLUE GELATINE SCREENS OVER EC-12 REFLECTORS — ANY COLOR SENSATION CAN BE OBTAINED — DIMMERS PLACED IN CIRCUIT TO CONTROL & PROPORTION COLORS — THE 500 W. CLEAR LAMPS USED WHEN COLORED EFFECTS ARE NOT DESIRED — INDIRECT LIGHTING PERMITS THOROUGH MIXING OF COLORS WITH LIGHT SOURCES CONCEALED



PLAN OF FIXTURE
SHOWING ARRANGEMENT OF X-RAY REFLECTORS WITH COLOR SCREENS

THE NATIONAL X-RAY REFLECTOR Co. CHICAGO & NEW YORK

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

DINING ROOMS

OTHER METHODS FOR DINING ROOM LIGHTING ARE GIVEN ON PAGES 66 AND 67.

SPECIAL APPLICATIONS ARE DESCRIBED ON PAGES 71, 75, 93 AND 111.

FACTORIES

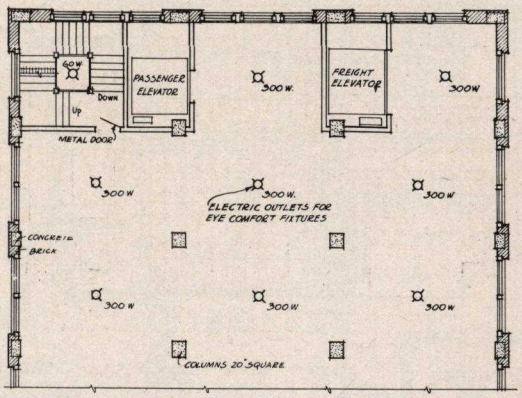
THE USE OF INDIRECT LIGHTING IN INDUSTRIES IS ILLUSTRATED ON PAGE 56.

FACTORY LIGHTING WITH DIRECT LIGHTING REFLECTORS IS FULLY TAKEN UP ON PAGE 129.

KELLOGG TOASTED CORN FLAKE COMPANY

· BATTLE CREEK · MICHIGAN ·

M. J. MOREHOUSE ARCHITECT · CHICAGO

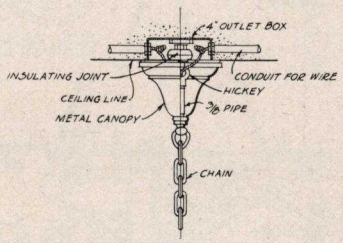


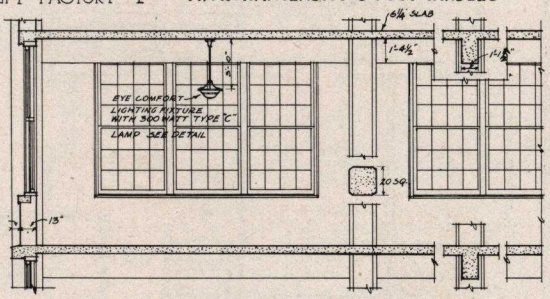
PART PLAN · 2ND FLOOR PACKING DEPT FACTORY #1

· INSTALLATION DATA ·

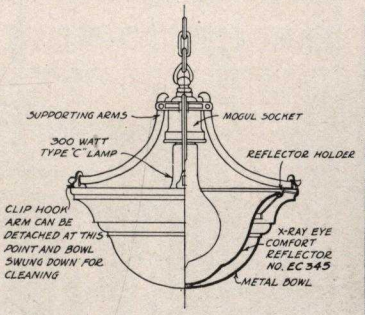
NOTE:- IN MODERN TYPE OF FACTORY BUILDINGS WHERE WALLS AND CEILING ARE WHITE AND ARE KEPT IN GOOD CONDITION "EYE COMFORT" INDIRECT LIGHTING CAN BE USED SUCCESSFULLY AND ECONOMICALLY WITH GENUINE X-RAY REFLECTORS THIS SYSTEM IS IDEAL FOR TEXTILE MILLS, PRINTING PLANTS AND WHEREVER INTRICATE OPERATIONS REQUIRE PERFECTLY DIFFUSED LIGHT

TYPICAL BAY FACTORY NO. 1 13' X 20'
AREA OF BAY 260 SQ. FT CEILING 13'-0"
ONE FIXTURE PER BAY. NO. 1321 TYPE WITH WHITE WASHABLE FINISH. 1-300 WATT TYPE "C" LAMP PER FIXTURE
WATTAGE PER SQ. FT. 1.15
TYPE OF REFLECTOR **EC 345**
3-0" FROM REFLECTOR TOP TO CEILING
APPROX. INTENSITY 5 FOOT CANDLES

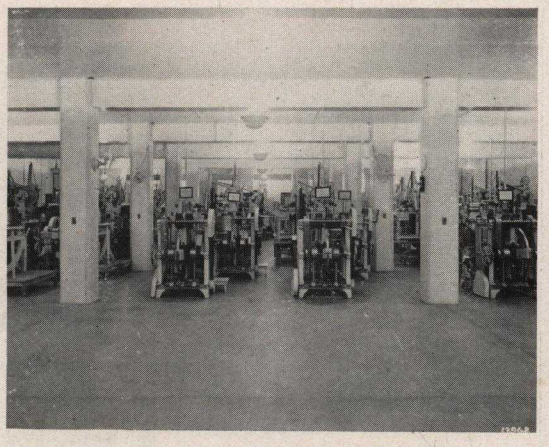




CROSS SECTION SHOWING TYPICAL BAY



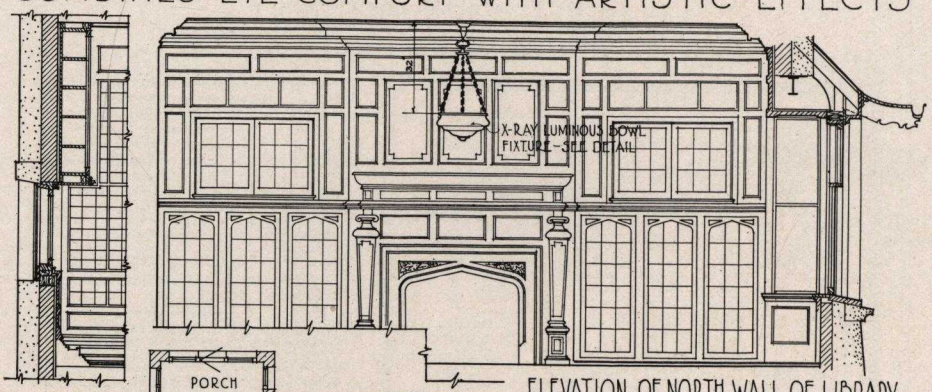
DETAIL OF EYE COMFORT LIGHTING FIXTURE



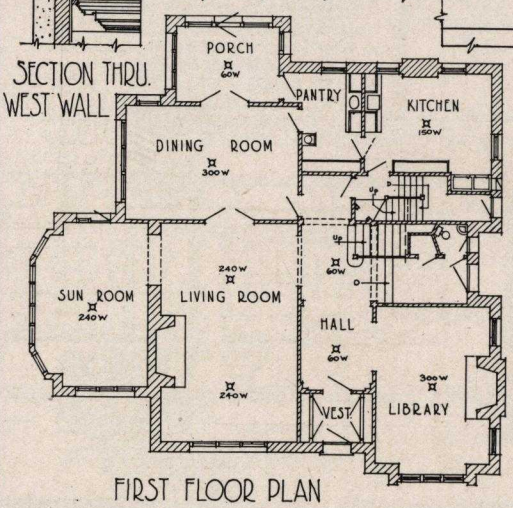
THE NATIONAL X-RAY REFLECTOR Co. CHICAGO & NEW YORK

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST

X-RAY INDIRECT LIGHTING FOR FINE RESIDENCE COMBINES EYE COMFORT WITH ARTISTIC EFFECTS

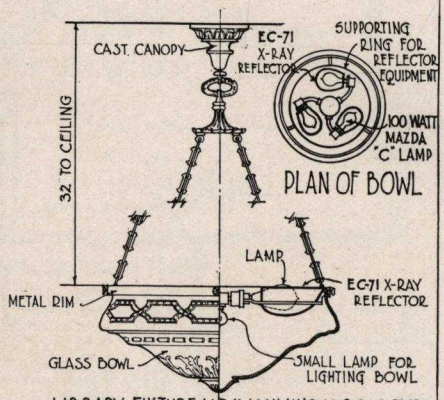


ELEVATION OF NORTH WALL OF LIBRARY



SECTION THRU. WEST WALL

FIRST FLOOR PLAN



PLAN OF BOWL

LIBRARY FIXTURE-X-RAY LUMINOUS BOWL TYPE

DESIGNED & EXECUTED BY OUR FIXTURE DEPT.

GENERAL NOTES

TO ASSIST IN THE SELECTION OF THE PROPER AMOUNT OF WATTAGE REQUIRED FOR VARIOUS ROOMS OF THE HOUSE IN WHICH X-RAY INDIRECT LIGHTING IS USED THE FOLLOWING TABLE IS GIVEN ÷

	WATT PER SQ. FT. OF FLOOR AREA
FOR LIVING ROOM USE	1.0
" HALLS (LOWER) "	.5
" HALLS (UPPER) "	.25
" SUN ROOM "	1.0
" DINING ROOM "	.75
" BATH ROOM "	.5
" LIBRARY "	1.0
" DEN "	1.0
" MUSIC ROOM "	.75
" BED ROOM "	.5
" DRESSING ROOM "	.5
" PORCH "	.5
" PLAY ROOM "	.5
" BILLIARD ROOM "	1.5
" KITCHEN "	1.0
" SEWING ROOM "	1.5

RESIDENCE OF MR. A.J. LINDEMANN. MILWAUKEE WIS.

NIGHT VIEW OF LIBRARY - INTERIOR MR. FITZHUGH SCOTT-ARCHT-MILWAUKEE WIS.

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

RESIDENCES

THE LIGHTING FOR ALL THE PRINCIPAL ROOMS OF THE HOME IS TAKEN UP ON PAGE 74.

ON PAGE 102 THE USE OF THE CURTIS PORTABLE INDIRECT LAMP IS DESCRIBED.

CHURCHES

THE LIGHTING OF CHURCHES IN GENERAL IS DESCRIBED ON PAGES 59 TO 61.

FOR THEIR ILLUMINATION WITHOUT FIXTURES, SEE PAGES 90 AND 113. FOR DIRECT LIGHTING IN THIS CLASS OF INTERIOR, SEE PAGE 158.

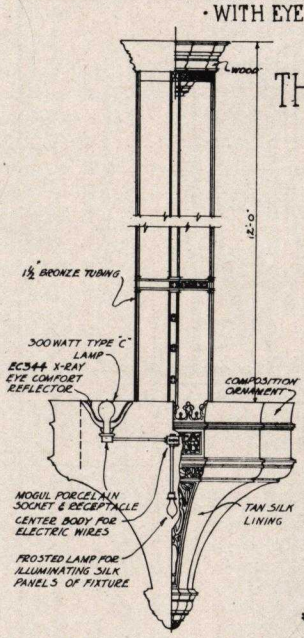
• WITH EYE COMFORT LUMINOUS BOWL FIXTURES • •

THE TIMOTHY EATON MEMORIAL CHURCH

TORONTO ONTARIO

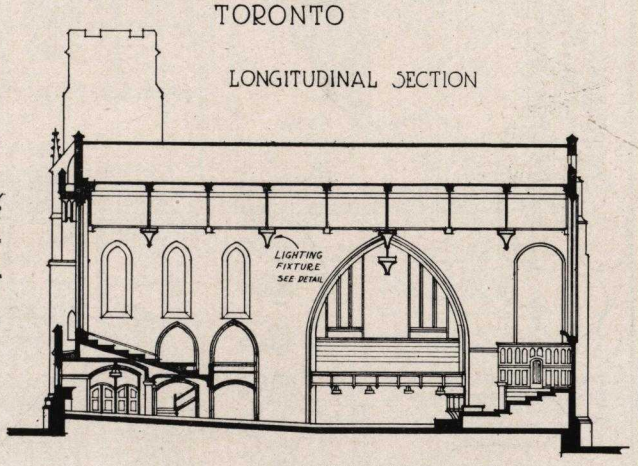
WICKSON & GREGG ARCHITECTS

TORONTO



ELEVATION OF UNIT

LONGITUDINAL SECTION



INSTALLATION DATA•

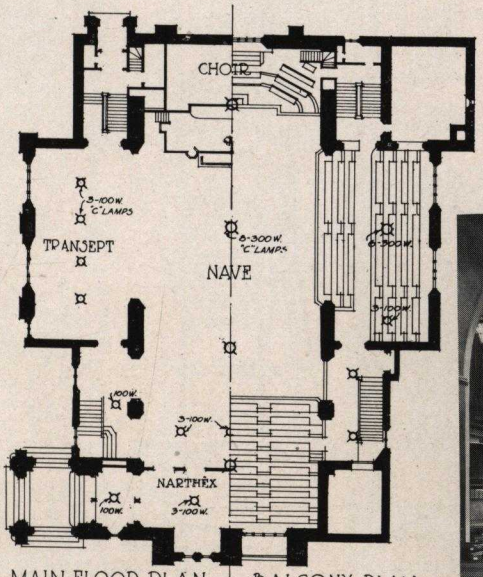
MAIN AUDITORIUM • 45'-0" X 120'-0" • 5400 SQ. FT. • 57' CEILING.
4 FIXTURES EACH WITH 8-300 WATT TYPE "C" LAMPS
REFLECTOR • EC344 SUSPENDED 12'-0" FROM CEILING
WATTS PER SQUARE FOOT 2.1

TRANSEPTS [EACH] • 23'-0" X 36'-0" • 674 SQ. FT. 32'-0" CEILING
ONE FIXTURE WITH 6-300 WATT TYPE "C" LAMPS.
REFLECTOR • EC344 SUSPENDED 12'-0" FROM CEILING.
WATTS PER SQUARE FOOT 2.1

SIDE BALCONIES [UNDER] • 23'-0" X 48'-0" • 1104 SQ. FT. 11'-0" CEILING.
4 FIXTURES EACH WITH 3-100 WATT TYPE "C" LAMPS,
REFLECTOR • EC15 SUSPENDED 36" FROM CEILING

REAR BALCONY [UNDER] • 15'-0" X 48'-0" • 720 SQ. FT.
3 FIXTURES EACH WITH 3-100 WATT TYPE "C" LAMPS.

FIXTURES CAN BE LOWERED TO FLOOR BY MEANS OF A WINCH SET ABOVE CEILING.

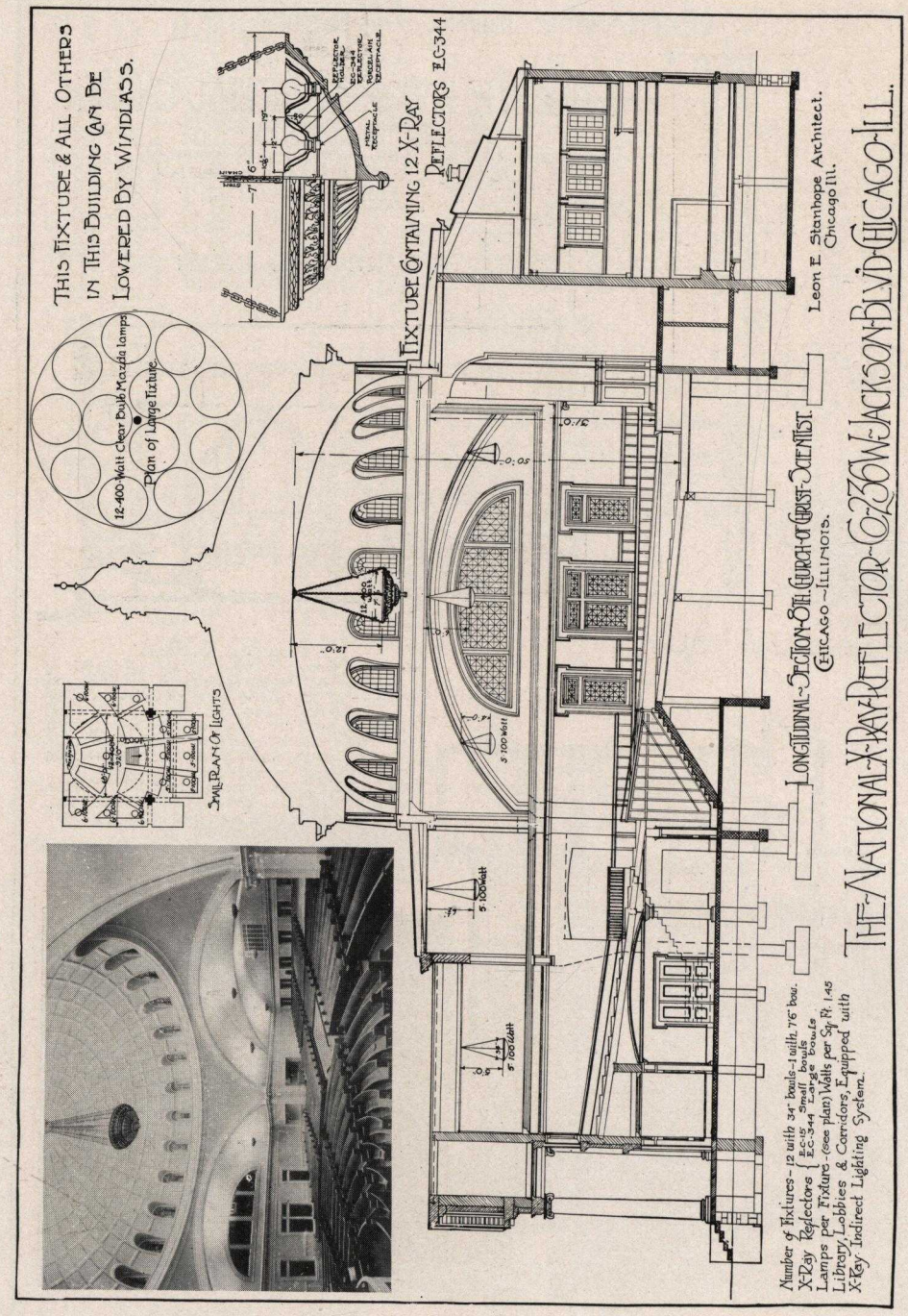


MAIN FLOOR PLAN

BALCONY PLAN

THE NATIONAL X-RAY REFLECTOR © CHICAGO & NEW YORK

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.



A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

CHURCHES

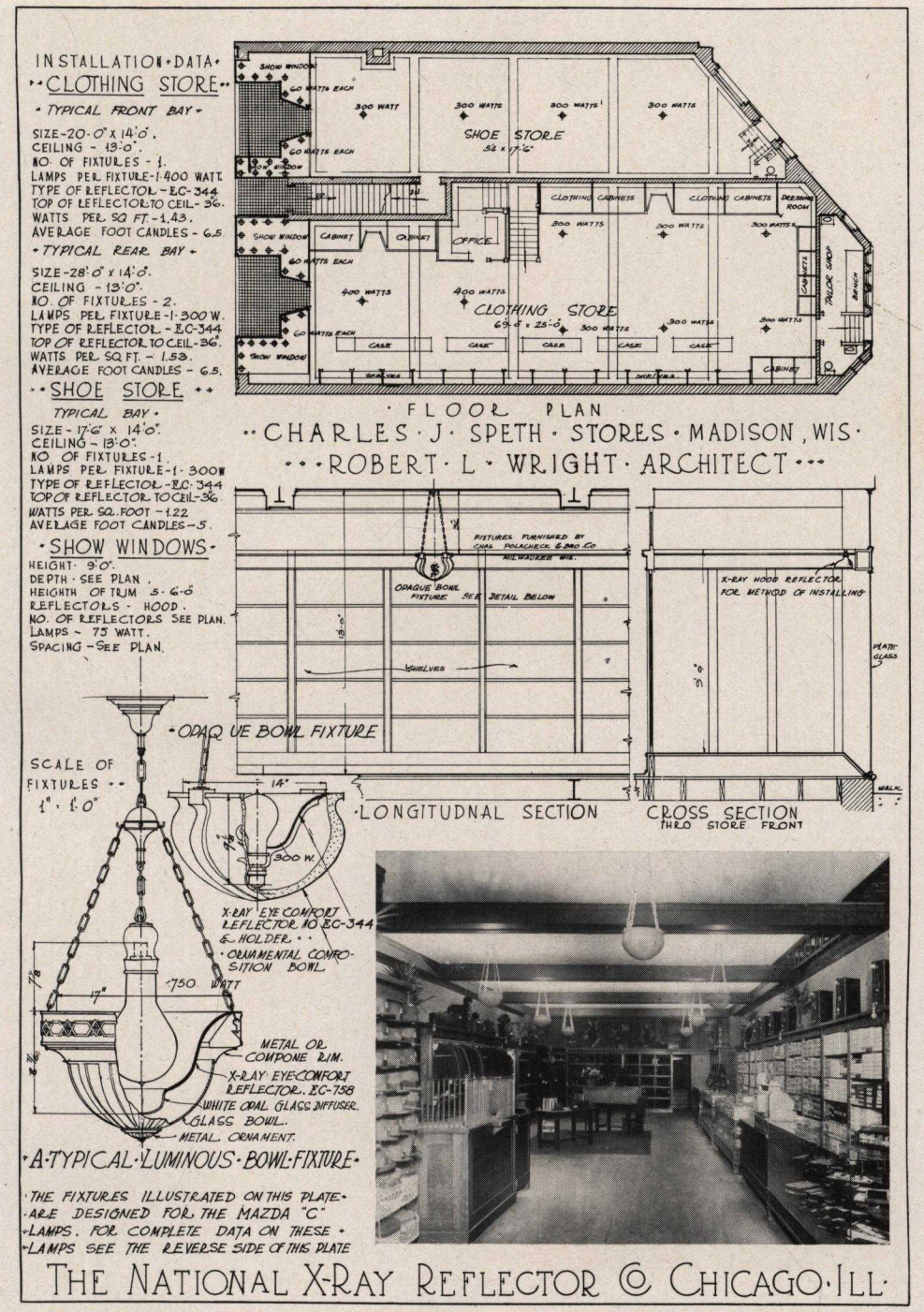
THE LIGHTING OF CHURCHES IN GENERAL IS DESCRIBED ON PAGES 59 TO 61.

FOR THEIR ILLUMINATION WITHOUT FIXTURES, SEE PAGES 90 AND 113. FOR DIRECT LIGHTING IN THIS CLASS OF INTERIOR SEE PAGE 158.

STORES

FOR COMPLETE INFORMATION ON LARGE AND SMALL STORES AND DISPLAY ROOMS, SEE PAGES 45 TO 49.

AN EXAMPLE OF STORE LIGHTING WITHOUT CEILING FIXTURES IS GIVEN ON PAGE 96.



A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

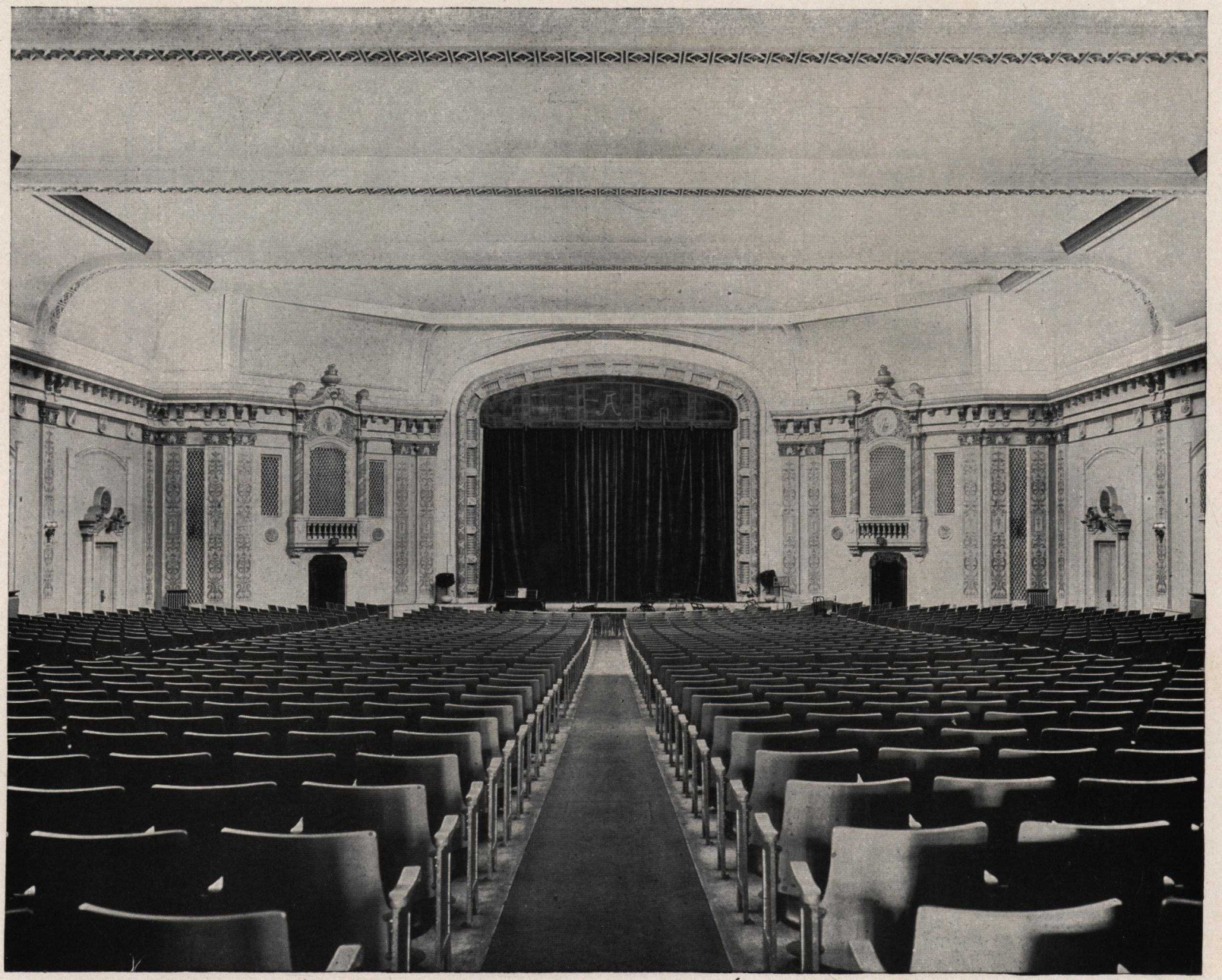


Fig. 147. The Auditorium, Adelphi Theatre, Chicago, Ill. J. E. O. Pridmore, Architect.

VI LIGHTING FROM OTHER THAN CEILING OUTLETS

COVES, CORNICES, FLOOR PEDESTALS, WALL BOXES, ETC.

Fig. 148. Garden foyer, South Shore Country Club, Chicago, Ill. Marshall & Fox, Architects.
This room, which is 35 feet wide and 43 feet long, is illuminated solely from one central floor pedestal containing two 500 watt lamps in X-Ray reflectors.

CEILING fixtures were no doubt first designed to provide a means of supporting candelabra and lamps at a central point, so that the four corners of the room would share equally in the radiance from the lighting unit.

Recent experiences have shown that ceiling fixtures are not always necessary; in fact, they often detract seriously from the harmony of the interior. Indirect illumination from other than fixtures suspended from the ceiling is a new and exceptionally beautiful method, made practical by the correct application of specially designed X-Ray reflectors. These reflectors can be most effectively used in obtaining novel lighting effects. The introduction of this method marks a new era in artistic lighting. *Much of the lighting of the future will be accomplished from sources entirely concealed, and without resorting to the use of hanging ceiling fixtures.*

Many interiors lend themselves to this kind of lighting treatment. The lighting units can be worked into the decorative elements, all lamps and reflectors entirely hidden from view yet the interior can be flooded with a clear, comfortable illumination by means of equipment which appears to be a decorative feature rather than a lighting fixture.

The reflectors can be concealed in projecting cornices and coves near the ceiling, placed in wall boxes, floor pedestals, columns, pilasters, on bookcases, mantels, pianos, or hidden in art lamps and urns. The method employed of course depends upon the individual conditions of each interior.

Some of the practical methods of lighting from other than ceiling outlets are shown on the pages that follow.

Particular attention is called to the additional interesting examples shown by the detail plates on pages 106 to 113.

COVES AND CORNICES

Fig. 149. St. Cyrils Church, Chicago, Ill. Joseph Molite Architect.

Indirect lighting from cornices is the oldest form of lighting from concealed sources. It was applied to large interiors in numerous instances in the early days of the incandescent lamp, and there is a record of its use many years ago with gas and even oil lamps. It was conceded to give excellent lighting results and to be the ideal method of displaying the architecture of the interior as a harmonious whole, but the waste of light was enormous, making such installations very expensive luxuries. With the advent of the modern high efficiency lamp new possibilities were opened up for the illuminating of interiors by this method.

The special X-Ray reflectors which have been developed have extended practical lighting methods so as to include the diversified conditions encountered, from the extremely high Gothic ceiling to the low basket-handled arch, or even flat ceiling.

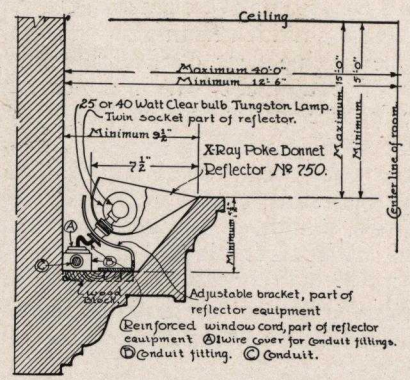


Fig. 150. Section of cove showing proper location of Poke Bonnet Reflectors, as used in St, Cyril Church, reflectors spaced 2-feet apart each with 2-40 watt lamps.

The efficiency of cornice installations now compares very favorably with installations using ceiling fixtures. In addition to the use of cove lighting in churches, and auditoriums, it is a practical method for theaters, ballrooms, lobbies and even residence lighting.

St. Cyrils' Church illustrated here is an excellent example of ceiling lighting without fixtures. Note how uniformly the ceiling is lighted—no splashes of light or blotches of shadows to indicate the position of the individual reflectors in the cove. This method gives the interior a spacious and dignified appearance. St. Cyrils' is a type. There are many churches like it. Cornice lighting is without question, the lighting for them.

Cove lighting is difficult to work out satisfactorily and requires more careful planning than the ordinary lighting problem. The fullest co-operation between the architect and lighting engineer will result in surprising and pleasing effects.

In the application of this method, the proper

FIRST CHURCH of CHRIST SCIENTIST
OAK PARK, ILL.
Auditorium

GENERAL NOTES:

Size of auditorium—74x95 feet.
Floor area—7030 square feet.
Height of ceiling—36 feet on center; 22 feet on sides.
Number of reflectors used in coves—107.
Kind of reflector employed—X-Ray No. E-65.
Lamps per fixture—1 100-watt Mazda "C."
Wattage consumed—1.52 watts per square foot.

Fig. 151. First Church of Christ Scientist, Oak Park, Ill. Leon E. Stanhope, Architect, Chicago, Ill.

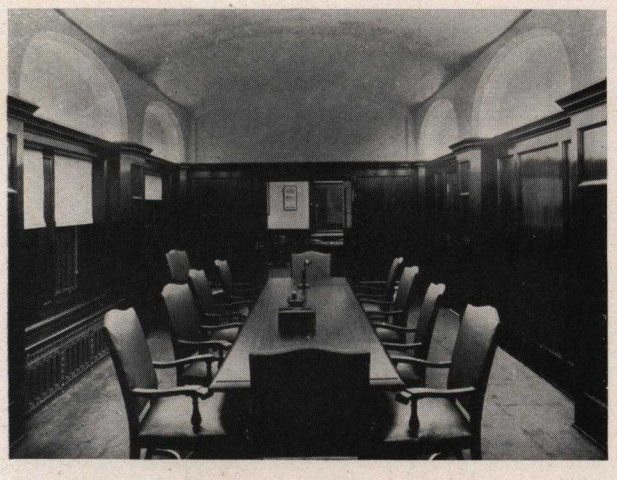


Fig. 152. Directors' conference room, Wisconsin Telephone Company, Milwaukee, Wis. Alex. C. Eschweiler, Architect.

size and style of reflector should be determined for the interior. The cove should be designed large enough to contain the specified equipment and should not be located too close to the ceiling in order that spotted and streaked effects will be minimized and the ceiling evenly lighted. A means should be provided whereby the reflector equipment can be easily reached for cleaning and renewal of lamps.

WISCONSIN TELEPHONE COMPANY MILWAUKEE, WIS.

Director's Room

GENERAL NOTES:

Size of room—15x28 feet.
Floor area—420 square feet.
Height of ceiling—12 feet.
Number of reflectors in the cove—68.
Type of reflector—X-Ray No. 515.
Lamps per reflector—1 25-watt-tubular.
Wattage consumed—4.0 watts per square foot.

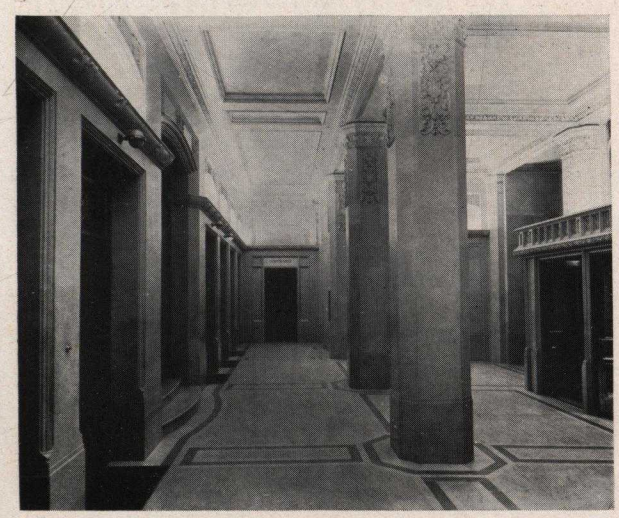


Fig. 153. Entrance Lobby—Wisconsin Telephone Company, Milwaukee, Wisconsin. Alexander C. Eschweiler, Architect.

Fig. 154. Motion picture theatre entrance lighted from cove near ceiling.

THE E-65 REFLECTOR

Many times it is not practical to construct a continuous cove in which to conceal the reflector but it is still desired to illuminate the interiors by means of hidden reflectors. To meet this condition, the E-65 X-Ray reflector has been developed. This unit can be used either in a continuous cove or can be located at various points about the room, on pilasters, posts, etc. Because of the special design and peculiar shape of this reflector, it can be placed directly against the wall and still not allow the light to splash on the side wall above the unit. The reflector is so designed that the light will be projected to the ceiling away from the wall, thereby eliminating the ugly and annoying light and dark areas which would ordinarily occur where special reflectors are not used.

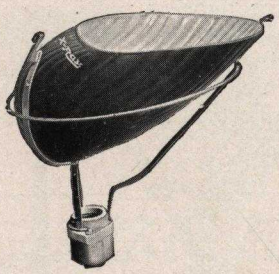


Fig. 155. X-Ray No. E-65 reflector for use with 100 or 150 watt Mazda "C" lamp.

The examples showing the application of the E-65 reflector indicate how the difficulties of cove lighting and side wall bracket lighting have been overcome with this special unit. A large field for illuminating interiors by the concealed light method has been opened up since this unit was developed.

BANK PARTITIONS

Fig. 156. Capital State Savings Bank, Chicago, Ill. Ottenheimer, Stern & Reichert, Architects.

The illustration above of the Capital State Savings Bank shows another instance of how lighting and architectural arrangement can be co-ordinated.

The illumination in this case is by means of indirect units located in boxes as indicated on the plan and section with auxiliary lamps and reflectors placed above the central skylights.

The lamps above the skylights are spaced so that the glass is uniformly illuminated giving about the same effect as with the indirect lighting.

General treatment of bank lighting employing X-Ray indirect lighting fixtures is given on page 44, and for a discussion on the lighting of bank cages, see page 225.

Sometimes the lighting units are placed in the top of the bank partition in a continuous row, in place of localizing them at specific points as shown here. The cornice then forms a continuous trough in which the reflectors are entirely concealed from view.

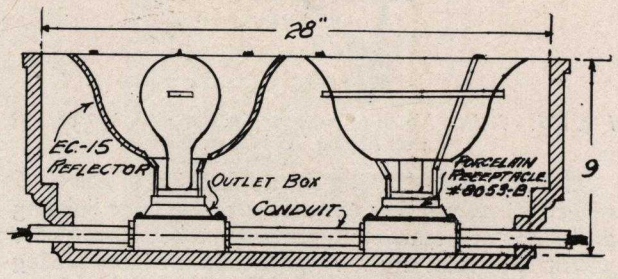


Fig. 157. Detail of the lighting box showing X-Ray reflector equipment.

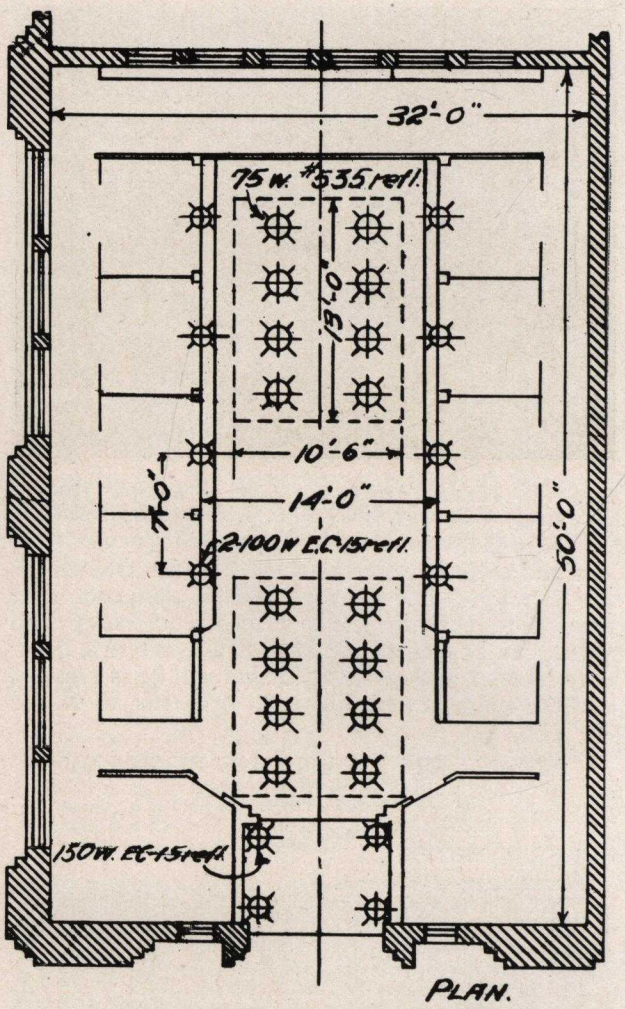


Fig. 158. Floor plan of the main banking space indicating the position of lighting units.

CAPITAL STATE SAVINGS BANK
CHICAGO, ILL.

GENERAL NOTES:

Size of room—32x50 feet.
Floor area—1600 square feet.
Height of ceiling—26 feet.
Number of fixtures—
  In boxes over cages 8,
  In boxes over entrance 4,
  Reflectors over skylight 16.
Type of reflectors used—
  In boxes over cages and entrance EC-15,
  Over skylight, No. 535.
Lamps per fixture—
  Over cages—2 100-watt,
  Over entrance—1 150-watt,
  Over skylight—1 75-watt.
Wattage consumed—
  For indirect lighting 1.38 watts per square foot.
  Skylight lighting—.75 watts per square foot.

Fig. 159. Dining room, Copley-Plaza Hotel, Boston, Mass.

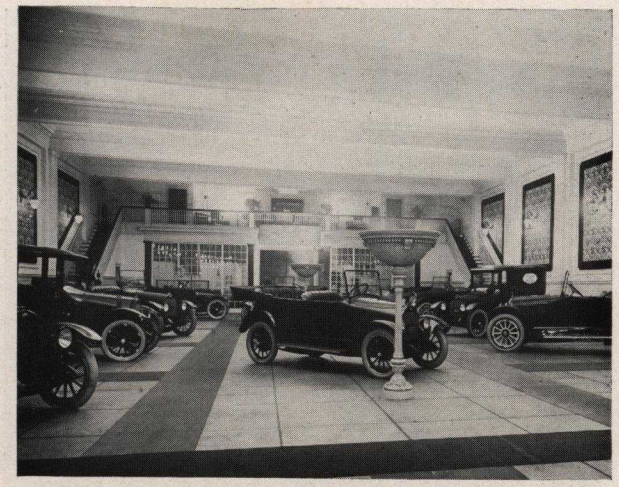


Fig. 160. Show room, Overland Motor Company, Chicago, Ill.

FLOOR PEDESTALS

It is a significant fact that a scheme of illumination from other than ceiling outlets should be selected for such high class interiors as the Coply Plaza Hotel, Boston, Mass.; Traymore Hotel, Atlantic City, N. J. (see page 106) and the South Shore Country Club, Chicago (see page 110). The architects for each of the above buildings decided upon lighting from floor pedestals as the most correct and logical solution.

Indirect lighting from floor outlets has been applied not only where novel lighting effects are wanted, but also when it is desired to illuminate the entire room from one or more centrally located positions.

In the case of the interior illustrated in Figure 159 above, the pedestal is to all intents and purposes merely a decorative receptacle for flowers. If proper equipment is installed, it will not be at once apparent that the light emanates from the bowl of the pedestal.

Careful adjustment is necessary in making an installation of this character to insure that the entire ceiling is evenly illuminated and to prevent sharp contrast between the ceiling and side wall illumination.

COPLEY-PLAZA HOTEL, BOSTON, MASS.

Dining Room

GENERAL NOTES:

Size of room—45x75 feet.
Floor area—2700 square feet.
Height of ceiling—20 feet.
Central lighting pedestal—8 feet high.
Pedestal contains—4 X-Ray No. 610 reflectors with 200-watt lamps; and 6 E-155 reflectors with 150-watt lamps.
Wattage consumed—.63 watt per square foot.
Small lamps back of art glass panels for decorative effect.

Automobile Show Room

An interesting example in concealed lighting for auto displays is found in the showroom of the Overland Co., Chicago, where a form of pedestal lighting is employed, as illustrated.

The side wall brackets shown in the picture are used merely for decorative effect and do not contribute to the general lighting of the room.
The detail of the pedestal used is shown below with a sectional view of the bowl, indicating the type of X-Ray equipment.

The details of the lighting for the display room of the Smith Form-a-Truck are given on page 108. This room is lighted in a unique manner by a cluster of units installed at the columns.

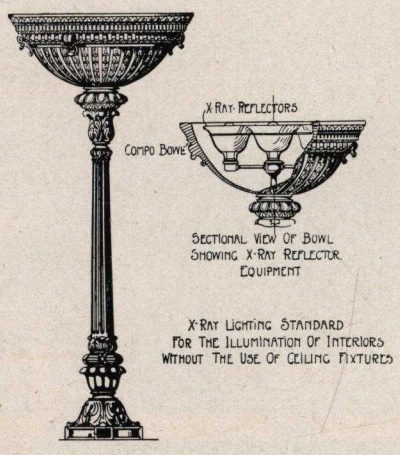


Fig. 161. Detail of the lighting standard for the Overland show room.

Fig. 162. Mezzanine floor, The Hub Store, Chicago, Ill. Marshall & Fox, Architects.

Balcony Pedestal Lighting

The balcony or mezzanine floor in a department store illustrated in Figure 162 is used as an annex to a main shce department. Ornamental standards or pedestals containing lamps and X-Ray reflectors are located at intervals along a line back of the chairs. The balcony is 12 feet wide, ceiling 9½ feet high and the distance from the top of the pedestal to the ceiling is 30 inches, pedestals are 10 feet apart and contain a 150 watt lamp with X-Ray reflector EC-15.

Pedestal lighting can be used very effectively where the ceiling is low.

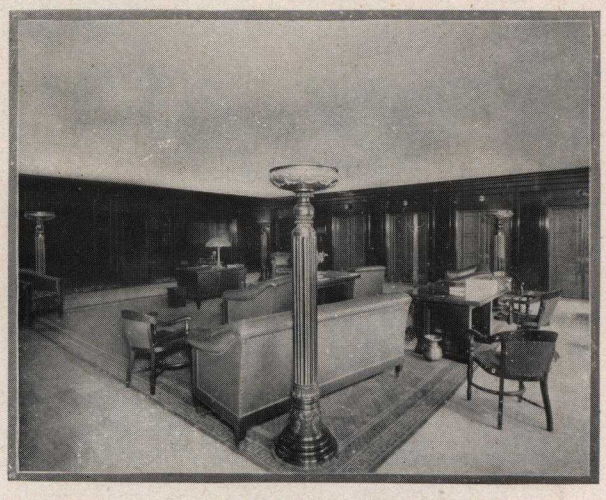


Fig. 163. Reception hall for executive offices, Commonwealth Edison Company, Edison Bldg., Chicago, Ill. Graham Burnham Co., Architects.

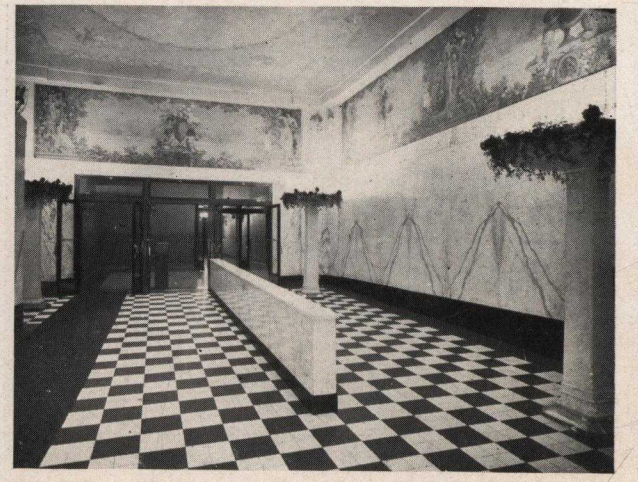


Fig. 164. Lobby, De Luxe Theatre, Chicago, Ill.

DE LUXE THEATER, CHICAGO, ILL.

Lobby

GENERAL NOTES:

Size of lobby—30x50 feet.
Floor area—1500 square feet.
Height of ceiling—20 feet.
Number of indirect lighting floor pedestals—4.
Height of pedestals—8 feet.
Type of reflector—X-Ray EC-15.
Lamps per fixture—4 100-watt.
Wattage consumed—1.07 watts per square foot.

Reception Hall

The reception hall for the executive offices of the Commonwealth Edison Co., Chicago, is illuminated by means of four permanently located standards of handsome carved mahogany, surmounted by rich, bronze urns or bowls containing three X-Ray reflectors, each of which holds a 150 watt lamp.

The circuit wires for the lamps pass down through the standard and communicate directly with outlets provided in the floor, below the rug. An unusually dignified effect in keeping with the surroundings is secured by this modern method, with no lights visible anywhere in the room.

COMMONWEALTH-EDISON COMPANY
CHICAGO, ILL.

Reception Room for Executive Offices

GENERAL NOTES:

Size of room—40x40 feet.
Floor area—1600 square feet.
Height of ceiling—10 feet.
Number of lighting pedestals—4.
Height of pedestals—6 feet 6 inches.
Reflectors for each pedestal—3 No. E-155.
Lamps per fixture—3 150-watt.
Wattage consumed—1.12 watts per square foot.

WALL BOXES

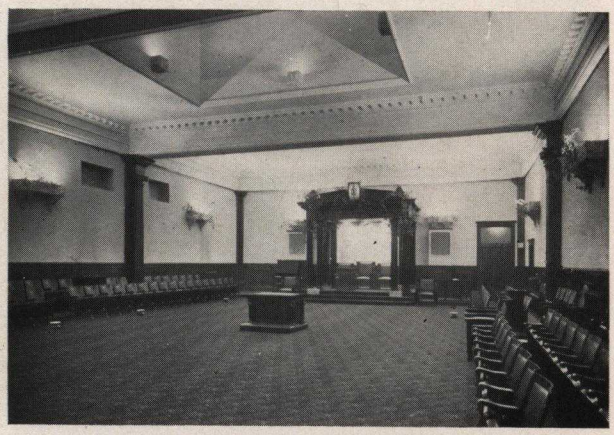


Fig. 165. Lodge room, Boulevard Masonic Hall, Chicago, Ill. Walter Ahlschlager, Architect.

The side walls of the room shown in Figure 165 are divided architecturally into three panels or spaces, hence a convenient and pleasing arrangement for the lighting units suggested itself, and one wall box equipped with specially designed X-Ray E-65 reflectors was located in each of the panels. The wall boxes at the end of the room are located over ventilating registers. In carrying out the decorative scheme of the room a symbolic emblem was painted on the wall just above each lighting box. These emblems stand out emphatically because of the light that falls upon them from the units in the boxes. The side wall boxes each contain four units. These boxes are 12 by 12 inches inside and 40 inches long. The floor plan, Figure 168, shows the location of the various units.

This wall box method is especially suitable for motion picture theatres (see page 109), since on obstruction is offered to the view or to the projection of the pictures.

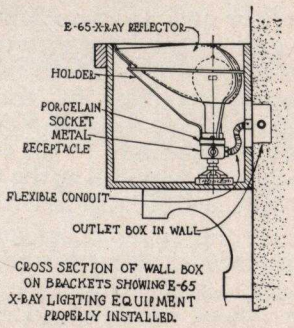


Fig. 166. Sectional view of wall box showing special X-Ray reflectors.

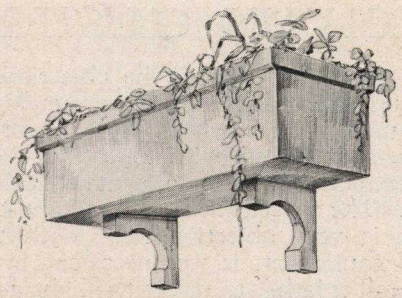


Fig. 167. An inexpensive wall fixture containing X-Ray No. E-65 reflectors for use in auditoriums and rooms where suspended fixtures are undesirable.

BOULEVARD MASONIC HALL, CHICAGO, ILL.

Lodge Room

GENERAL NOTES:

Size of room—44x62 feet.
Floor area—2728 square feet.
Height of ceiling—19 feet.
Number of lighting boxes—
On side walls—6, each with 4 100-watt lamps.
At ends of room—4, each with 2 100-watt lamps.
In skylight well—4, each with 1 60-watt lamp.
Wattage consumed—1.26 watts per square foot.
Type of reflector used—X-Ray E-65.
Top edge of lighting boxes 12 feet from floor.

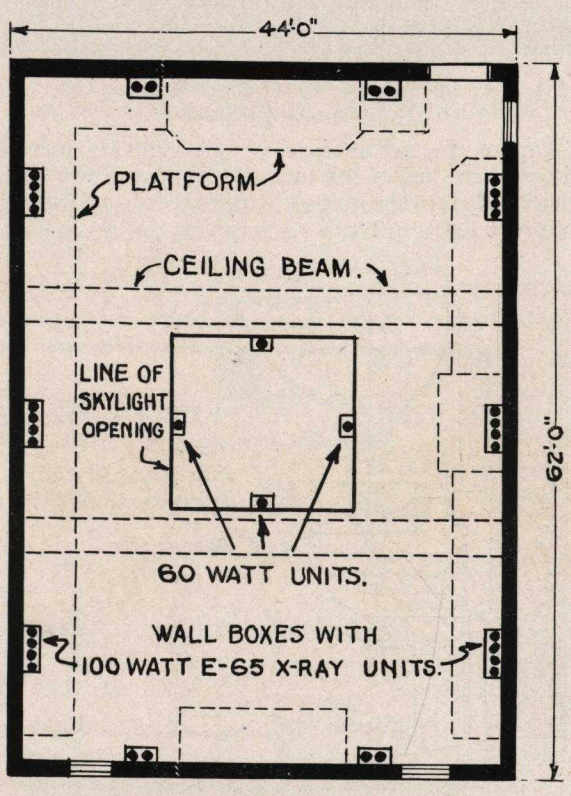


Fig. 168. Plan of Boulevard Masonic Hall.

COLUMN CLUSTERS

"Wall splash" is one of the objections usually brought up against lighting systems employing cove lighting units, wall brackets, etc. These methods have been employed with disastrous results in many installations using a symmetrical type of reflector. The concentrated spot of light just above the unit is very objectionable. With the older forms of equipment, it was necessary in order to avoid "wall splash," to direct the light away from the wall by protecting the unit or shielding it in some manner, thereby sacrificing the efficiency.

Fig. 169. Interior view Mather store, Pasadena, Cal. John Parkinson, Architect. E. Metcalf, Interior Designer.

One of the advantages of the lighting methods shown here lies in the fact that it leaves the ceiling clear and gives the interior a more roomy appearance. Indirect lighting tends to raise the ceiling, which is most desirable in low rooms and adds a subtle charm not obtainable with ceiling fixtures.

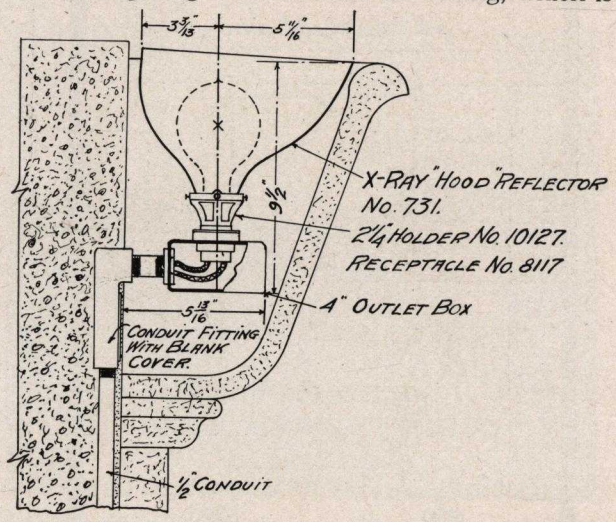


Fig. 170. Sectional diagram showing wiring arrangements for column bracket fixture.

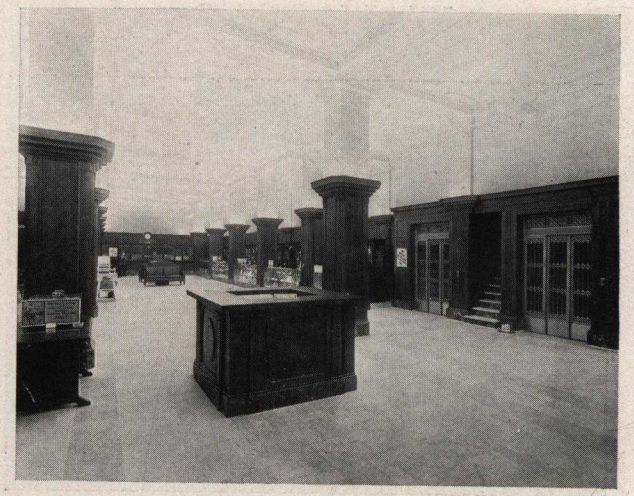


Fig. 171. Lobby — Minneapolis General Electric Company, Minneapolis, Minn. Bertrand & Chamberlin, Architects. Chas. L. Pillsburg Co., Engineers.

Figure 169 shows a view in the Mather Store, Pasadena, California where X-Ray E-65 reflector units are used in column cluster fixtures. A unique *column cluster* installation is shown on page 108.

Minneapolis General Electric Company

Central Station Companies are looked upon by the general public to set the standard of illumination. Therefore, the methods employed by the central station in lighting their own buildings has an important effect upon the uses of artificial lighting.

The details of the lighting installation in the Minneapolis General Electric Company offices are interesting. The lobby is uniformly illuminated to a high intensity without the aid of a single ceiling fixture. This adds to the massive appearance of the room and harmonizes perfectly with the general constructive scheme carried out in the design and decorations.

Dark fumed oak woodwork is used with a light cream marble floor and cream columns and beams. The center panels in the bays between the beams are finished in a flat white smooth finish to obtain the best reflecting condition for the illuminating units. A total of 190 No. E-65 X-Ray Cove Lighting Reflectors direct the light to the ceiling and are enclosed in the spaces provided at the top of the column panels. The ceiling is 18 feet high.

The offices on the upper floors are illuminated with X-Ray Indirect Lighting fixtures, both of the luminous bowl and metal bowl type. The principal executive offices, main corridors, credit department, and part of the bookkeeping department are lighted with the luminous bowl fixtures.

Fig. 172. Banking room, American Express Company, New York City, Renwick, Aspinwall & Tucker, Architects.

COLUMN BRACKETS

A most interesting example of lighting without ceiling fixtures is to be found in the banking room of the general offices of the American Express Company at No. 65 Broadway, New York City. Special bronze brackets designed to harmonize with the architecture of the building, located on the columns and pilasters, furnish all the general illumination for this interior.

The plan below in the diagrams show clearly how this remarkable indirect lighting result is accomplished. Each of the brackets contains an X-Ray No. 600 Jove reflector, whose top edge is 60 inches from the ceiling line. The 200 watt Mazda "C" lamp has been installed for each unit. The illumination for the upper floors of the building which are used for general office purposes is furnished by X-Ray luminous bowl fixtures.

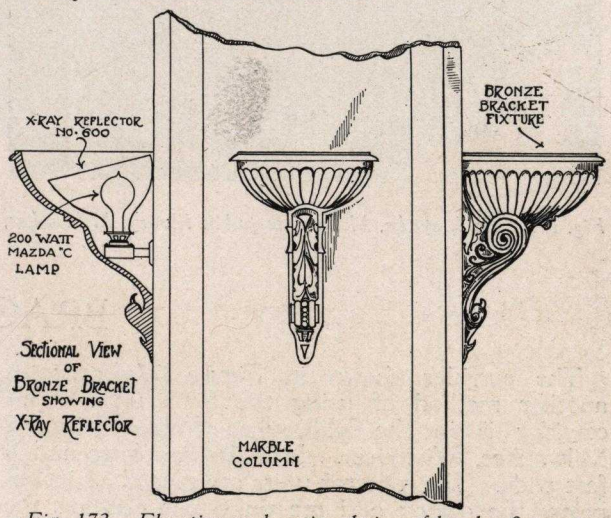


Fig. 173. Elevation and sectional view of bracket fixtures.

AMERICAN EXPRESS COMPANY, NEW YORK CITY

Banking Room

GENERAL NOTES:

Size of room—76x208 feet.
Floor area—14,000 square feet.
Height of ceiling—18 feet 6 inches.
Number of bracket units—116.
Type of reflector in brackets—X-Ray No. 600.
Lamps per fixture—1 200-watt.
Wattage consumed—1.58 watts per square foot.
Reflector units placed 5 feet from ceiling.

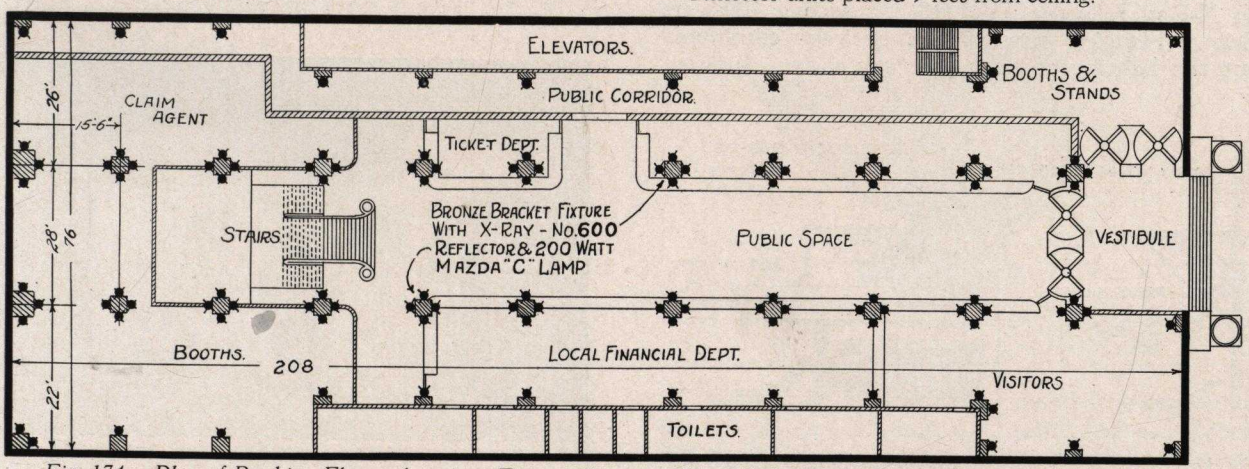


Fig. 174. Plan of Banking Floor—American Express Company, New York. Showing location of bracket lighting units.

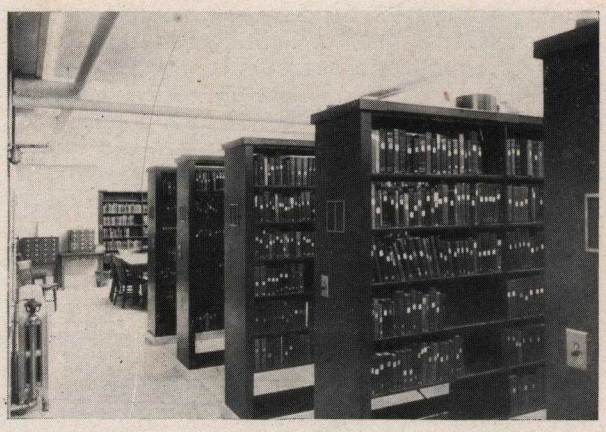


Fig. 175. Book stacks, Milwaukee public library, Milwaukee, Wis.

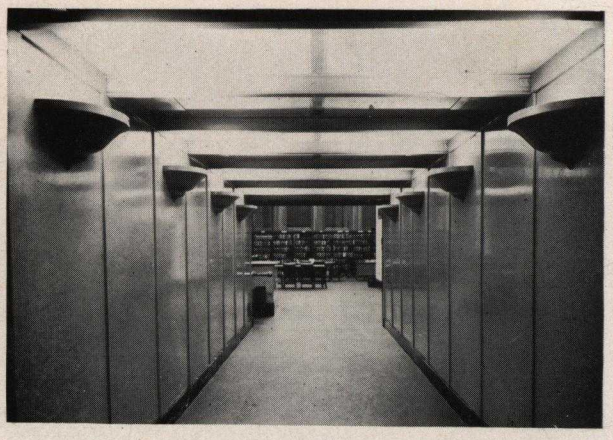


Fig. 177. Corridor leading to reading room, Milwaukee public library, Milwaukee, Wis.

BRACKETS

The corridor shown in Figure 177 illustrates another method of using the E-65 unit. This corridor is in the Milwaukee Public Library, Milwaukee, Wisconsin. It is 26 feet long and 8 feet wide. The reflector units are placed 22 inches below the ceiling and are on 6-foot centers, the end units being 4 feet from the ends of the corridor. A total number of eight reflectors are used, each equipped with one 60-watt Mazda lamp. The reflectors are enclosed in a unit of spun steel, the spinning being cut in half, the back soldered in and riveted to the steel side of the corridor.

An interesting and practical method of lighting book stacks is shown in Figure 175. The details of the fixture are shown in Figure 176. In this case, the lighting unit consists of a cylindrical housing mounted on top of the book stack and containing an X-Ray reflector unit, EC-15, with a 100-watt lamp. Hanging fixtures are entirely eliminated but the lighting effect is just the same. Indirect illumination is an ideal method for book stacks, inasmuch as titles on the lower shelf are just as easily read as those on the upper shelf.

In the Baptistry of the St. Phillips Church, Rugby, England, where the ceiling is but 7 feet, 6 inches high, it was necessary to resort to a rather special indirect lighting method. The Baptistry is 11 feet, 9 inches square and is lighted by two side wall indirect brackets as shown in Figure 178. These brackets each contain one 40-watt tungsten lamp and an X-Ray E-40 one-piece, silvered reflector.

The method pictured is especially applicable where the ceiling of the room is low and where the use of hanging fixtures or a system of direct lighting fixtures supported on stems or brackets would be impracticable on account of head room. The appearance of the room is also increased by the use of hidden lighting receptacles.

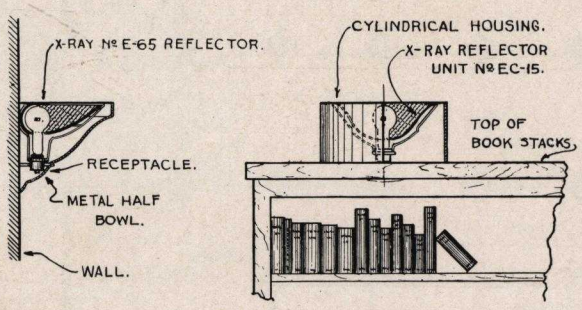


Fig. 176. Details of lighting units for book stacks and corridor, Milwaukee public library, Milwaukee, Wis.

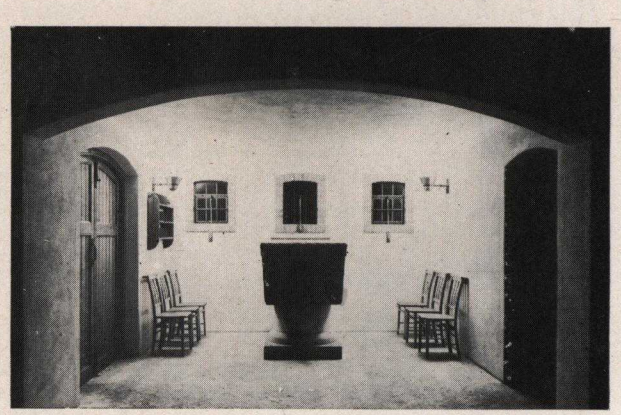


Fig. 178. Baptistry, St. Philips Church, Rugby, England.

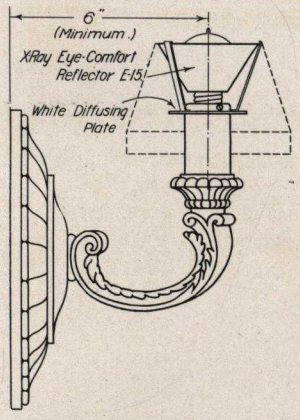


Fig. 180. Diagram of indirect lighting bracket.

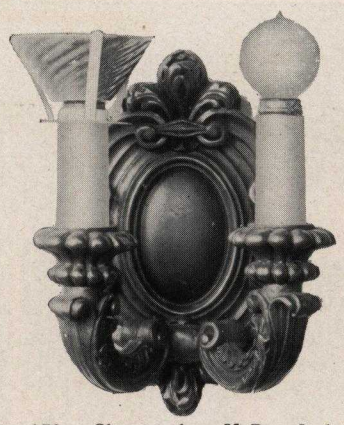


Fig. 179. Showing how X-Ray Indirect Adapter may be readily attached to wall bracket.

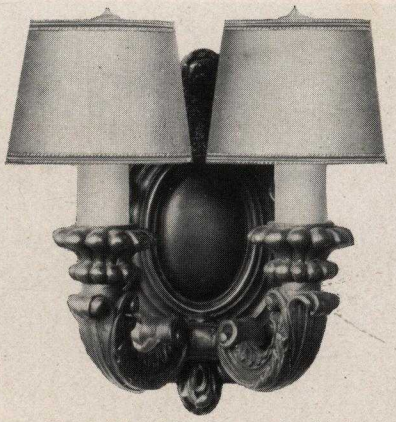


Fig. 181. Bracket with shade concealing equipment.

INDIRECT CANDELABRA BRACKETS

In many interiors, especially residences, hotels, clubs, etc., it is desirable to add a touch of refinement and cheerfulness by the use of indirect candelabra brackets.

Since their function is chiefly ornamental, it is advisable to use small sized lamps. The brackets illustrated above are designed for use with 10 or 15 watt tungsten lamps. The reflector equipment used for the brackets is very similar in construction to the Curtis Portable adapters for indirect art lamps shown on page 101.

The silk shade is softly illuminated by the small amount of light which comes through the opening in the bottom of the reflector. This light is reflected against the inner surface of the shade by a white diffusing plate. Direct lighting candelabra brackets may be easily converted to an indirect bracket by simply adding the small adapter and silk shade.

SPECIAL CONTAINERS FOR INDIRECT REFLECTORS

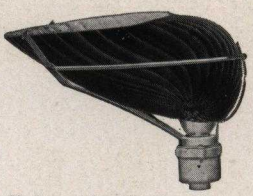


Fig. 182. The X-Ray No. E-65 reflector unit for 60-watt Mazda "B" lamp.

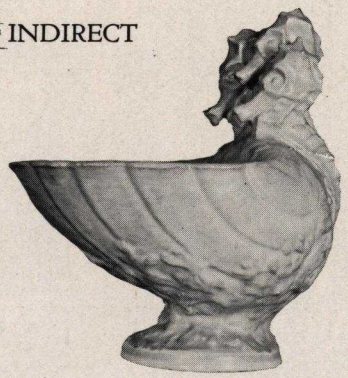


Fig. 183. Ornamental container for X-Ray E-65 reflector for lighting from mantels, book cases, etc.

A unique and artistic way of room lighting that gives a delightful effect is that of utilizing one, two or more special receptacles placed upon mantels, bookcases or piano tops. To completely hide the lamp and reflector, the receptacle should be placed above the eye level.

The illustration given here is only one suggestion for many ways in which the special X-Ray reflector No. E-65 can be housed in ornamental containers and produce special lighting effects.

Fig. 184. Illumination from an art lamp as it is ordinarily employed, giving a bright localized light directly under the lamp.

Fig. 185. The same room as illustrated above charmingly illuminated by a flood of clear, indirect light reflected from the ceiling. The indirect illumination comes from special equipment concealed inside the shade; thus, by the pull of a switch, the lamp will give two lighting effects.

VII THE CURTIS PORTABLE LAMP

ITS USE IN THE HOME AND OTHER INTERIORS

THE Curtis Portable lamp described on the following pages is one of the most novel and attracive lighting devices that has yet been developed. It is another one of the numerous applications of the X-Ray system of indirect illumination.

This system originally was applied to ceiling fixtures only, with hanging bowls, with which everyone is familiar. It is just as easy and practicable however with this lighting system to put the ceiling to work by means of portable lamps, wall brackets and other artistic variations as well as by means of fixtures suspended from the ceiling.

An art lamp equipped with a Curtis Portable adapter can be made to serve two purposes as far as illumination is concerned. It will light the area immediately under the lamp with the effect obtained by the ordinary table lamp. By the pull of a switch, it will also flood the entire room with a clear bright illumination. Both of these effects are very graphically illustrated on the opposite page. The adapter is entirely concealed within the silk shade so that the appearance of the art lamp remains unchanged.

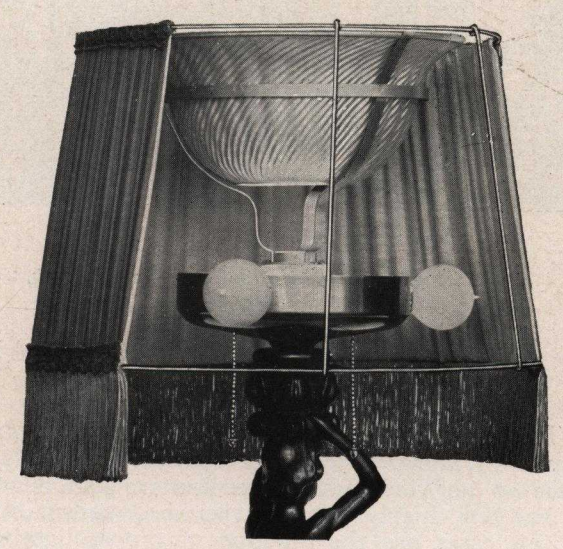


Fig. 187. The Curtis Adapter showing how it is concealed within the shade.

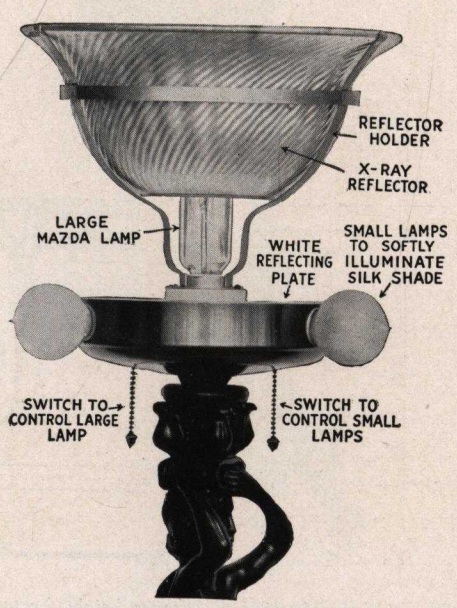


Fig. 186. The Curtis Indirect Adapter for portable lamps.

THE MECHANISM

The accompanying illustration, Figure 186, explains the simple mechanism of the adapter. Pulling one of the switches lights the small lamps around the edge of the disc, giving the shade the illuminated decorative effect of the usual art lamp. When a general illumination of the room is desired, pulling the other switch turns on the large Mazda lamp contained and hidden within an opaque X-Ray reflector. The light from this lamp and reflector is thrown to the ceiling and from there diffused throughout every corner and part of the room.

The powerful corrugated reflector is held in a correct position with relation to the lamp to secure the most efficient results.

The bottom of the X-Ray reflector is open and a small per cent of the light from the large lamp strikes the white surface or plate of the disc body. This light is reflected against and illuminates the shade making the use of the small lamps unnecessary when the indirect light is turned on.

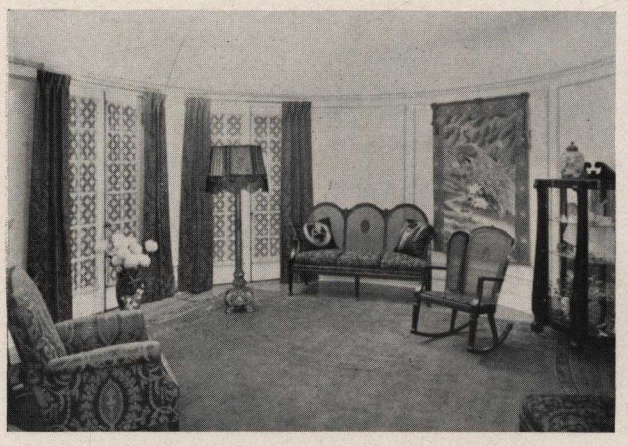


Fig. 188.

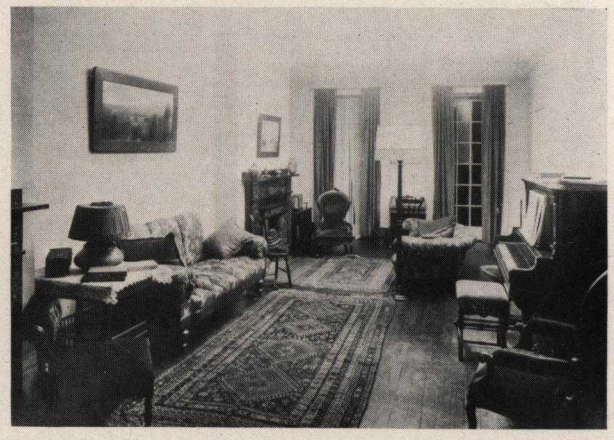


Fig. 189.

Living rooms lighted with Curtis portable lamp, without the use of ceiling fixtures or wall brackets of any kind.

CURTIS PORTABLE IN THE HOME

The art lamp has found great favor in the American home, yet in many instances it is of little or no value from a utilitarian standpoint. It has been highly developed as an ornament but in few cases has the question of proper lighting effect been seriously considered. Bare unshaded lamps have been allowed to glare into the eyes because the shade did not cut off the light at the proper angles. Or the standards for the lamps have been too high, thus exposing the bulbs to the view of anyone sitting at the table. Many heavily shaded lamps do not give sufficient light for general illumination of the room.

The Curtis Portable lamp was designed originally for the home. The increasing popularity of X-Ray indirect lighting in the home brought about the idea of combining the indirect lighting feature with that of the beautiful art lamp.

The photograph shown in Figure 188 illustrates a typical living room lighted with this indirect lamp. The lamp need not be located in the center of the room. For residence lighting especially, there is considerable latitude as to the placing of the lamp. In Figure 189 for instance, the lamp is placed near the wall at one side of the room. The most pleasing effects are obtained in this manner as the illumination is not of the same intensity all over the room, but decreases gradually from locations near the lamp to the further corners, giving a more cozy and home-like effect than if the lamp were placed immediately in the center of the room.

The Curtis Portable lamp is appropriate for parlors, living rooms, music rooms, bed chambers, etc. It is usually attached to outlets in the baseboard.

Surprisingly good results are obtained in the home with this Portable lamp for a low wattage consumption. A 100 watt lamp is usually sufficient for a room 12 by 16 feet. This means a little over one-half a watt for each square foot of floor area.

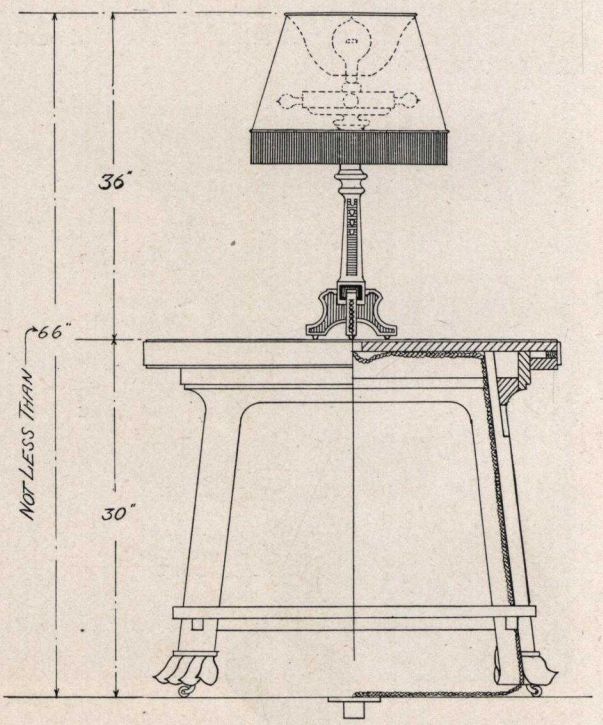


Fig. 190. Diagram showing the proper height for table lamp with Curtis indirect adapter.

ADAPTABILITY TO LAMP STANDARDS

Pedestals of metal, wood and composition, large vases, heavy candlesticks and any suitable standards may be converted into beautiful art lamps by equipping them with Curtis adapters of the various types shown on page 105. Typical lamps are shown on this page.

In adapting standards, care must be taken that the large powerful reflector is always above the line of vision. The Curtis Portable adapter is 12 inches high. The floor lamp standard therefore should be at least 54 inches high and the table lamp standard at least 24 inches high. If the standards do not measure up to these dimensions, a short pipe extension can be easily attached to the top of the standard before installing the adapter. The minimum overall heights for floor and table lamps are given in the diagrams of Figures 190 and 192.

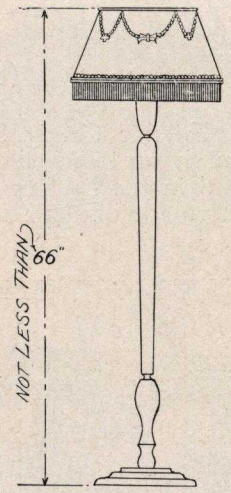


Fig. 192. Diagram showing the proper height for floor portable with Curtis indirect adapter.

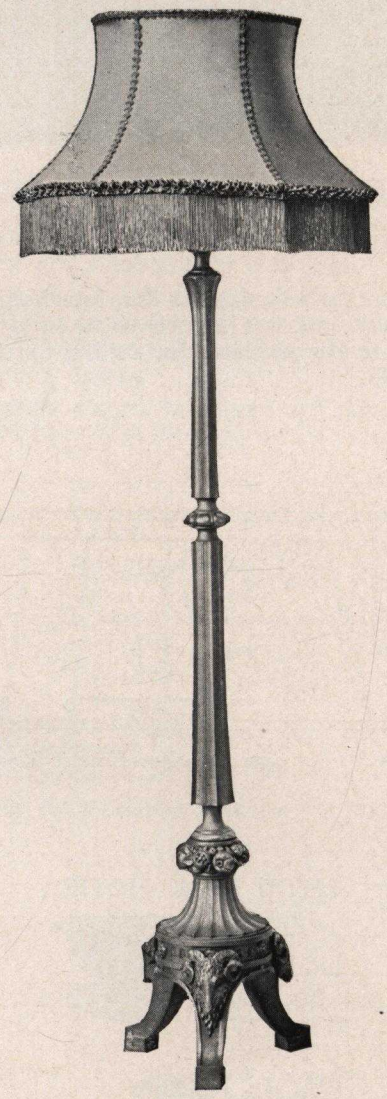


Fig. 191. Carved wood floor lamp with old gold silk shade, gold polychrome finish.

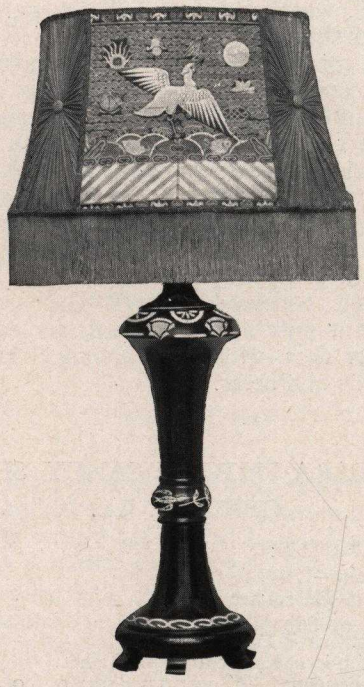


Fig. 193. Turned wood with Japanese silk shade finished in mahogany with decorations in gold.

OTHER USES FOR CURTIS PORTABLE LAMP

The Barbara Fritchie Candy Shop and Hyde Park Tea Room shown in the illustrations typify the modern trend in the lighting of smart shops, confectionery stores, millinery shops, tea rooms, restaurants, etc.

Fig. 194. Barbara Fritchie Candy Shop, Chicago, Ill.

Art lamps, while they are recognized as the highest type of artistic fixture, have been useless to the shop keeper because the light furnished, while ornamental, was insufficient. The Curtis Portable has altered this condition because of its power to flood large rooms with a clear and ample illumination from concealed sources. It has come into great demand by the owners of smart shops in the cities large and small. In Figure 194 is illustrated one of a series of small candy shops, all of which are equipped with this lamp. No ceiling fixtures or bracket lights are used. The only other lighting equipment is that employed for the show windows and consists of X-Ray Jupiter No. 610 reflectors. The wattage consumed in the Barbara Fritchie installation is only about one watt for each square foot of floor area, which is economical for installations of this character.

Fig. 195. Tea room, Hyde Park Hotel, Chicago, Ill. W. L. Stebbins, Architect.

Illumination calculations for interiors in which the portable indirect lamp is to be used are made similarly to the methods for ceiling fixtures given on page 33.

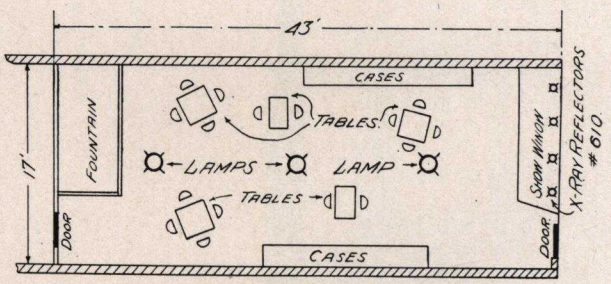


Fig. 196. Floor plan of Barbara Fritchie Candy Shop.

BARBARA FRITCHIE CANDY SHOP
CHICAGO, ILL.

GENERAL NOTES:

Size of room—17x43 feet.
Floor area—731 square feet.
Height of ceiling—11 feet.
Number of Curtis Portables—3.
Size of lamp in each Portable—200 watt.
Wattage consumed—.82 watts per square foot.
Show windows lighted with X-Ray reflectors—No. 610 and 100 watt lamps.

HYDE PARK HOTEL,
CHICAGO, ILL.
Tea Room

GENERAL NOTES:

Size of room—23x56 feet.
Floor area—1188 square feet.
Height of ceiling—12 feet.
Number of Curtis Portables—8.
Size of lamp in each Portable—100 watt.
Wattage consumed—.68 watts per square foot.

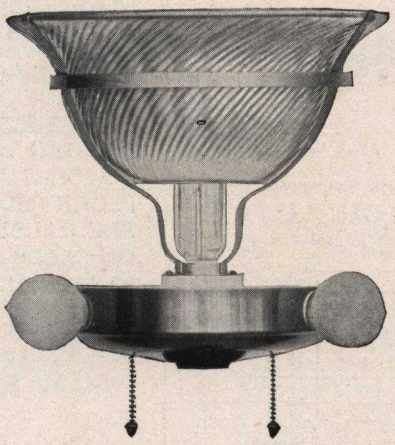


Fig. 197. Curtis Indirect Adapter, Type No. 2853.

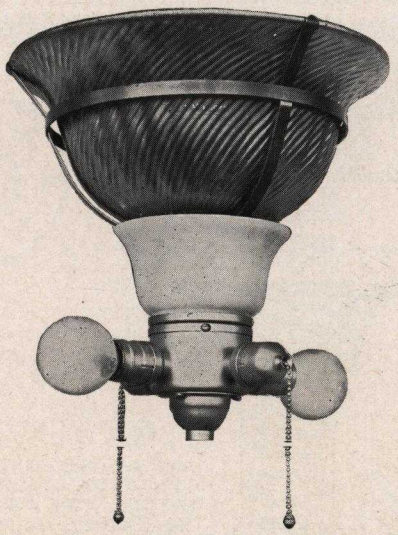


Fig. 201. Curtis Indirect Adapter, Type No. 2831.

CURTIS PORTABLE ADAPTER

The principal types of adapters are shown by the illustrations and diagrams on this page.

The type of adapter shown in Figure 197 has a 12-inch X-Ray reflector for use with a 200-watt Mazda "C" lamp and arranged for three auxiliary direct lighting lamps.

The adapter shown in Figure 201 has a 12-inch reflector for use with 100, 150 or 200 watt Mazda "C" lamp and arranged for two auxiliary direct lighting lamps. It will be noted that this adapter does not have the reflecting disc body but is equipped with a special diffuser to provide the illumination for the silk shade when the small side lights are not burning. This adapter can also be furnished with a 9½-inch reflector for use with a 100, 150 or 200 watt Mazda "C" lamp. Both of the above types of adapters are tapped for fastening to a ⅜-inch iron pipe.

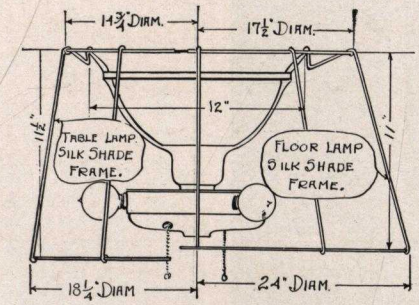


Fig. 198. Diagram of Adapter No. 2853.

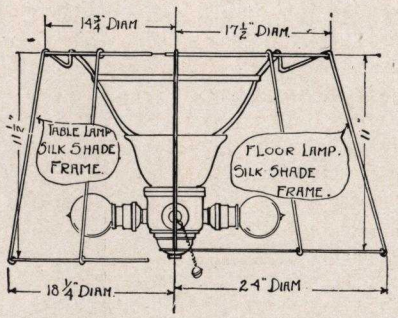


Fig. 202. Diagram of Adapter No. 2831.

Fig. 199

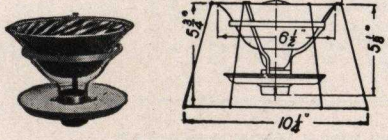
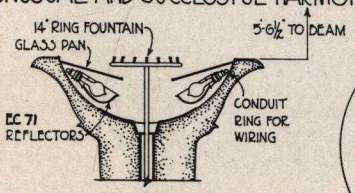


Fig. 200

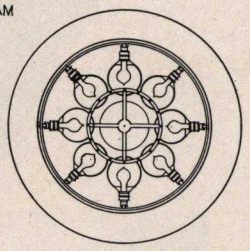
A small adapter with 6½-inch reflector for use with 25, 40 and 60 watt lamps is shown in Figure 199. This adapter can be used with heavy brackets and will fit on a standard brass shell socket.

A still smaller type of adapter is shown in Figure 200, equipped with a 4⅛-inch reflector and intended for 15 or 25 watt round bulb lamps. This adapter is for use with small candle brackets and will fit any brass shell standard socket or 1¼-inch metal candle.

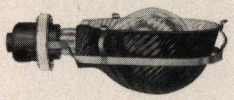
UNUSUAL AND SUCCESSFUL HARMONY OF ARCHITECTURAL AND LIGHTING TREATMENTS



SECTION

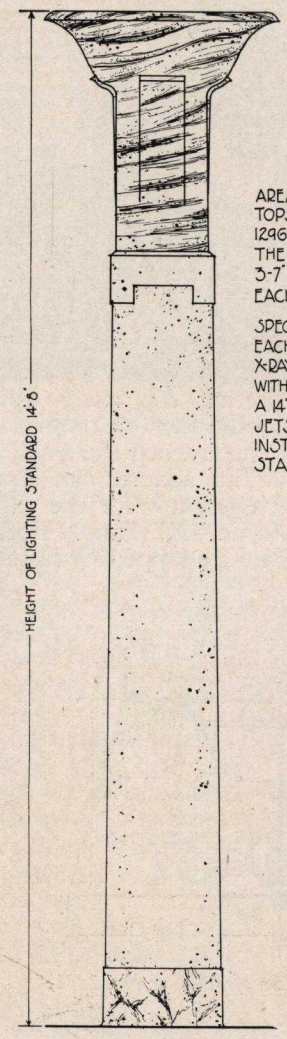


PLAN
LOOKING DOWN



NO. EC 71 REFLECTOR UNIT
FOR 75 · 100 AND 150 WATT MAZDA "C" LAMPS

USED IN LIGHTING STANDARDS. LAMPS BURN IN A NEARLY HORIZONTAL POSITION. CORRUGATIONS IN REFLECTOR BREAK UP AND DIFFUSE THE LIGHT.

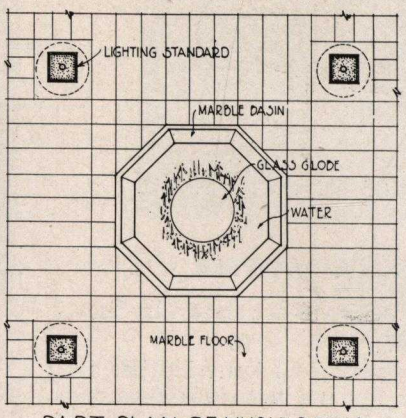


ELEVATION OF FIXTURE
COLUMN IN WHITE CEMENT
BOWL OF MARBLE

GENERAL NOTES

AREA 36-0"X36-0 LIGHTED FROM TOPS OF FOUR STANDARDS. OR 1296 SQ. FT. CEILING HEIGHT 22'-2½" THE STANDARDS ARE 14-6" HIGH. 3-7" ACROSS TOP. AND 18-0" APART EACH WAY

SPECIAL LIGHTING EQUIPMENT IN EACH STANDARD CONSISTS OF 8 X-RAY EC 71 REFLECTOR UNITS WITH 150 WATT MAZDA "C" LAMPS A 14" RING FOUNTAIN WITH SMALL JETS OF WATER POINTING IN IS INSTALLED IN THE TOP OF EACH STANDARD.



PART PLAN OF MUSIC ROOM

THE MUSIC ROOM · HOTEL TRAYMORE · ATLANTIC CITY
PRICE AND McLANAHAN ARCHITECTS
PHILADELPHIA

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

HOTELS

THE LIGHTING OF HOTELS IS DISCUSSED ON PAGE 52.

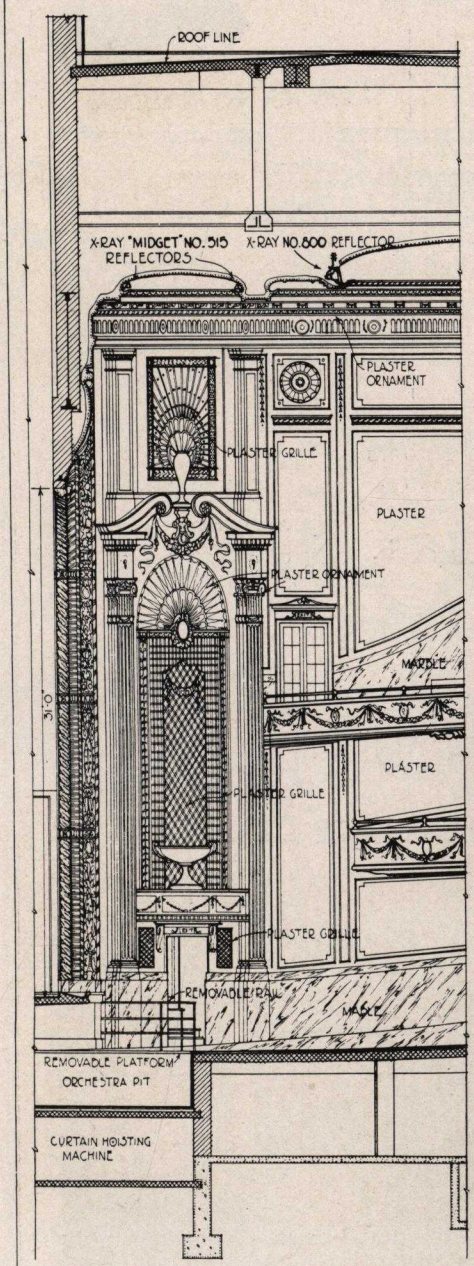
HOTEL DINING ROOMS LIGHTED WITH FIXTURES AND FLOOR PEDESTALS ARE ILLUSTRATED ON PAGES 66, 67, 82 AND 111.

THEATRES

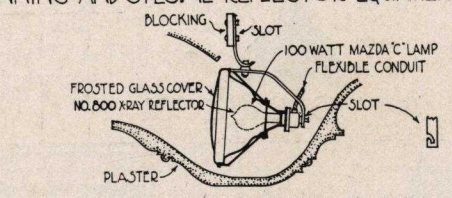
THE REQUIREMENTS FOR THE LOBBY, FOYER AND AUDITORIUM OF THE THEATRE ARE DISCUSSED ON PAGE 64.

FOR COVE LIGHTING, THE USE OF WALL BOX UNITS, ETC., SEE PAGES 91, 94 AND 109, AND FOR STAGE LIGHTING SEE PAGES 148 AND 153

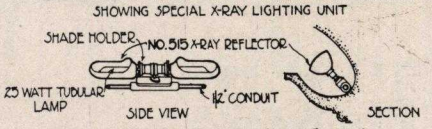
COVE LIGHTING REQUIRES CAREFUL PLANNING AND SPECIAL REFLECTOR EQUIPMENT



PART SECTION ON CENTER LINE
SHOWING PROSCENIUM DECORATION



SECTION THROUGH CENTER ELLIPSE
SHOWING SPECIAL X-RAY LIGHTING UNIT



SHOWING X-RAY EQUIPMENT IN SMALL PANELS

GENERAL NOTES

FLOOR SPACE OF AUDITORIUM ABOUT 60'X 80'-4800 SQ FT. CEILING HEIGHT AT CENTER 50 FEET. ILLUMINATION ACCOMPLISHED BY SPECIAL X-RAY COVE LIGHTING UNITS IN CEILING. CENTER ELLIPTICAL COVE CONTAINS 36 X-RAY PROJECTOR TYPE REFLECTORS, 4 FEET ON CENTER WITH 100 WATT MAZDA "C" LAMPS, DIFFUSING AND HEAT RESISTING COVER GLASS OVER MOUTH OF EACH REFLECTOR. REFLECTOR, COVER, SOCKET AND LAMP MAY BE LIFTED OUT OF COVE FOR CLEANING AND LAMP REPLACEMENT.
SMALL COVES IN SIDE CEILING AREAS CONTAIN X-RAY "MIDGET" REFLECTORS NO. 515 ON TWIN SOCKETS 2 FEET ON CENTER, WITH 25 WATT TUBULAR LAMPS IN EACH OF THE "MIDGET" REFLECTORS

INTERIOR · THE RIALTO THEATRE · CHICAGO
MARSHALL & FOX ARCHITECTS
CHICAGO ILLINOIS

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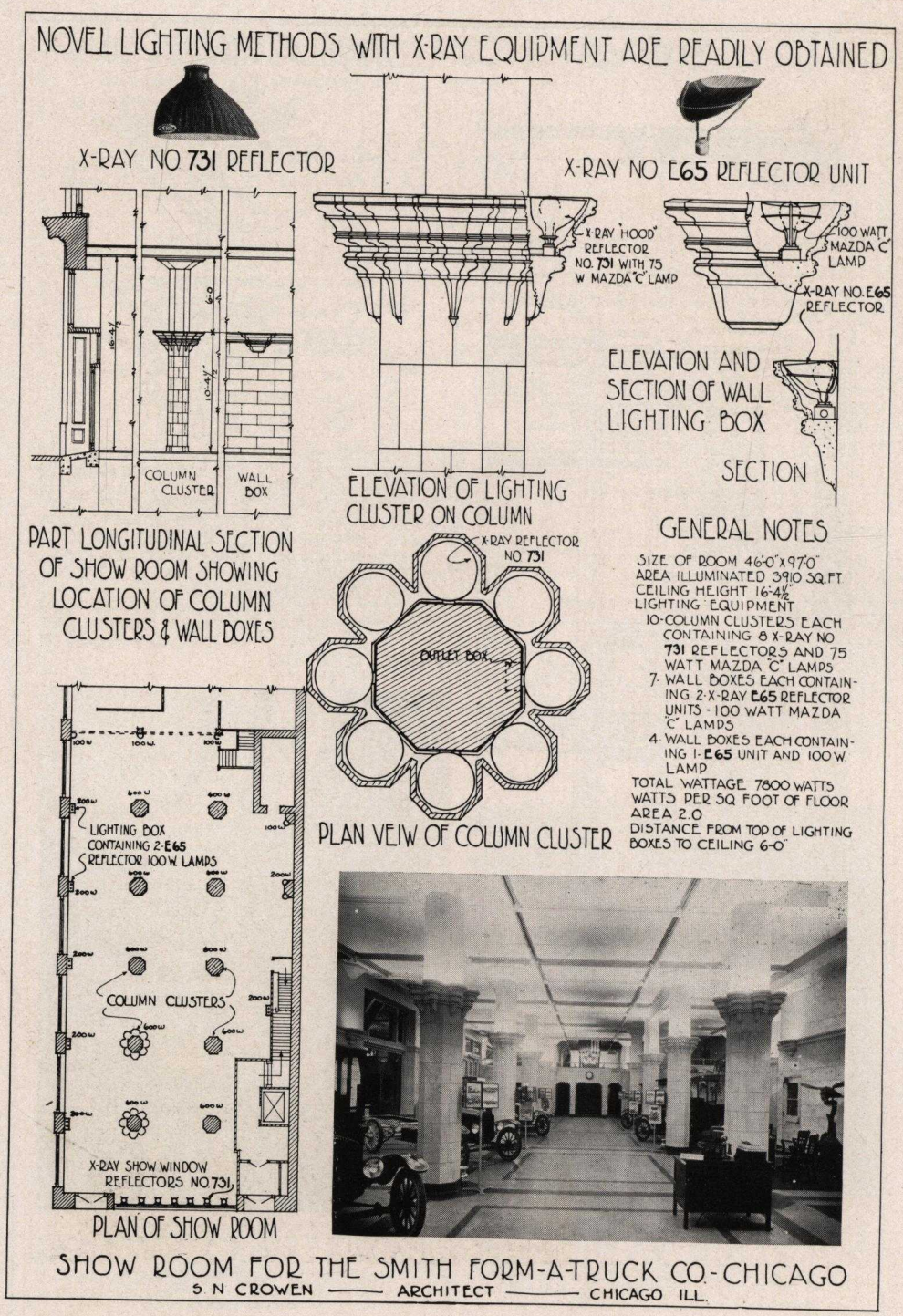


DISPLAY ROOMS

THE LIGHTING OF DISPLAY ROOMS AND SHOW ROOMS WITHOUT FIXTURES IS FURTHER DESCRIBED ON PAGE 93.

REFERENCE SHOULD ALSO BE MADE TO PAGE 49.

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

THEATRES

THE REQUIREMENTS FOR THE LOBBY, FOYER AND AUDITORIUM OF THE THEATRE ARE DISCUSSED ON PAGE 64.

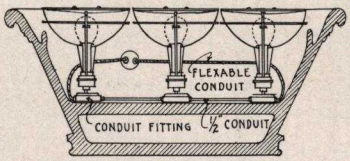
FOR COVE LIGHTING, THE USE OF WALL BOX UNITS, ETC., SEE PAGES 91, 94 AND 107 AND FOR STAGE LIGHTING SEE PAGES 148 AND 153.

· PARKSIDE THEATRE ·

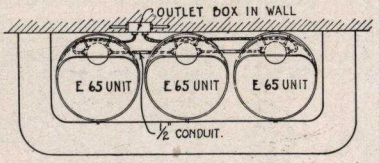
· CHICAGO ILL. ·

· ADOLF WOERNER —— ARCHITECT ·

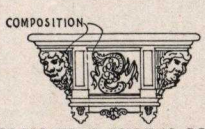
NO. E 65 X-RAY REFLECTOR UNIT.



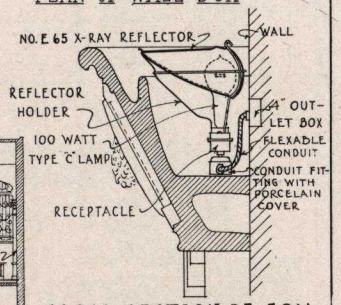
LONGITUDINAL SECTION OF WALL BOX
SHOWING WIRING CONNECTION



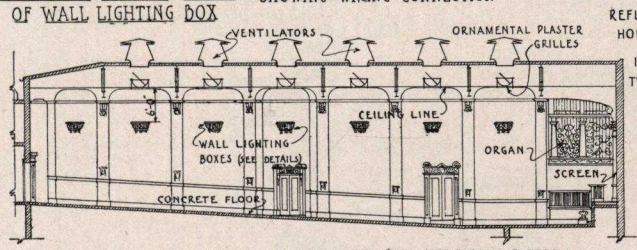
PLAN OF WALL BOX



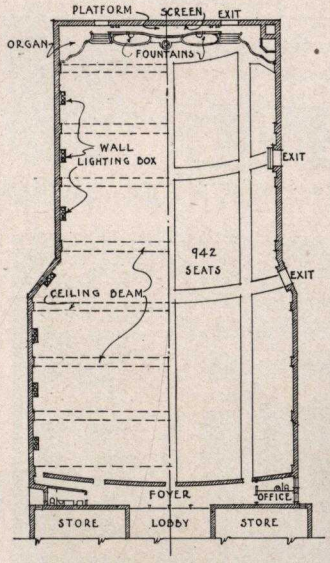
ELEVATION SHOWING DESIGN OF WALL LIGHTING BOX



CROSS SECTION OF COMPOSITION WALL BOX
SHOWING SPECIAL X-RAY LIGHTING EQUIPMENT-



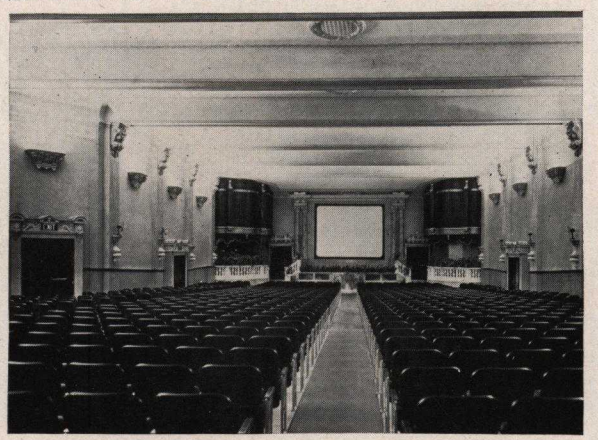
LONGITUDINAL SECTION OF AUDITORIUM



PLAN OF AUDITORIUM

· INSTALLATION DATA ·

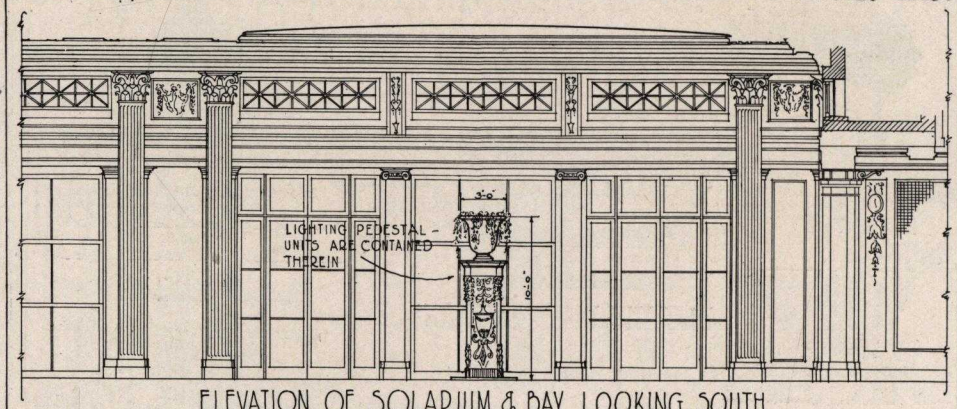
AUDITORIUM - SIZE 60'-0" X 100'-0" — FLOOR AREA 6600 SQ. FT.
AVERAGE CEILING HEIGHT 24'-0" - LIGHTING FROM 14 SIDE WALL BOXES
TYPE OF REFLECTOR UNIT X-RAY **NO. E-65**
3 UNITS PER BOX, WITH 100 WATT TYPE C LAMPS
UNITS WIRED IN TWO CIRCUITS CONTROLLED FROM OPERATORS ROOM
ONE UNIT PER BOX PROVIDS DIM ILLUMINATION DURING PERFORMANCE
1400 WATTS OR .21 WATTS PER. SQ. FT.
ALL UNITS BURNING DURING INTERMISSION GIVES BRIGHT ILLUMINATION
4200 WATTS OR .64 WATTS PER SQ. FT. — BOXES LOCATED 6'-0" FROM CEILING



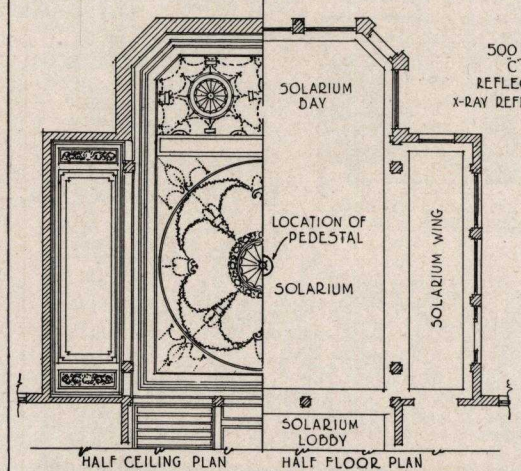
THE NATIONAL X-RAY REFLECTOR Co. CHICAGO & NEW YORK

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST

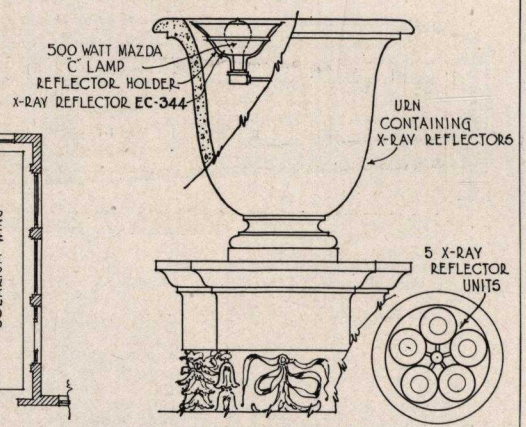
DIGNIFIED, MELLOW LIGHTING OF UNUSUAL BEAUTY FOR RICHLY APPOINTED CLUBS



ELEVATION OF SOLARIUM & BAY LOOKING SOUTH



PLAN OF SOLARIUM



DETAIL OF LIGHTING PEDESTAL—PLAN OF URN

GENERAL NOTES

AREA OF SOLARIUM PROPER 43-6" X 43-6" OR 1892 SQ. FT.
CEILING HEIGHT 21-0"
LIGHTING STANDARD-10-0" HIGH 3-0" ACROSS TOP OF URN, CONTAINS FIVE (5) X-RAY NO. EC-344 REFLECTOR WITH 500 WATT MAZDA C LAMPS
WATTAGE CONSUMPTION 1.32 WATTS PER SQ. FT.
AREA OF SOLARIUM WING 14-6" X 45-0" OR 652 SQ. FT.
AREA OF SOLARIUM BAY 17-10" X 43-6" OR 775 SQ. FT.
CEILING HEIGHT 14-4"

FOR ORNAMENTAL PURPOSES BAYS AND WINGS HAVE LANTERN TYPE FIXTURES PENDANT FROM CEILING CONTAINING LOW WATTAGE LAMPS
BEAUTIFUL COLOR LIGHTING EFFECTS ARE PRODUCED IN THE SOLARIUM SPACE BY PLACING COLOR SCREENS ABOVE THE REFLECTOR UNITS

GARDEN FOYERS OF THE CLUB ARE ALSO LIGHTED WITH THE X-RAY PEDESTAL SYSTEM

SOLARIUM IN THE CLUB HOUSE OF THE SOUTH SHORE COUNTRY CLUB-CHICAGO
MARSHALL & FOX — ARCHITECTS — CHICAGO ILL.

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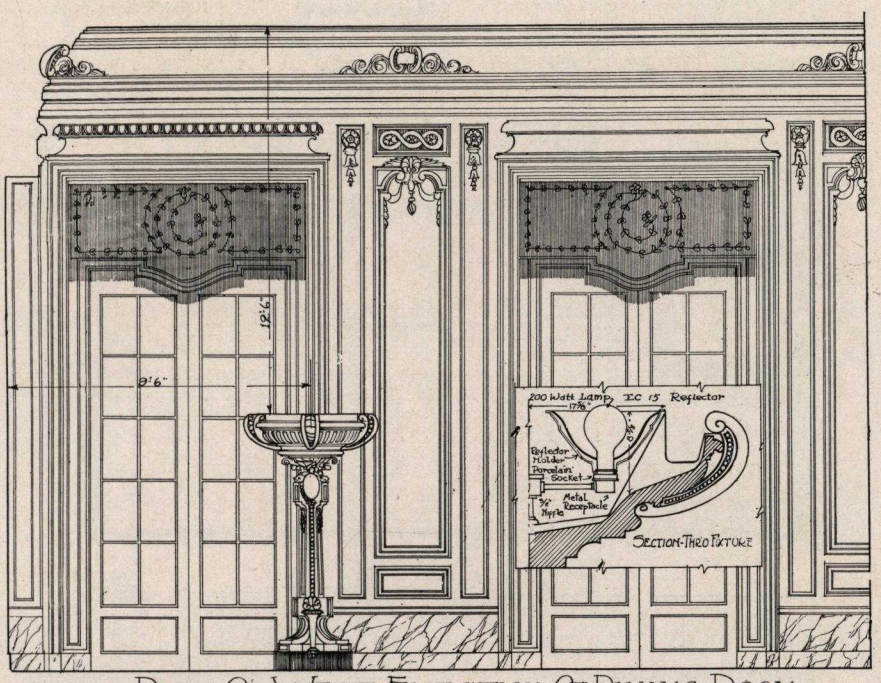
CLUBS

A DISCUSSION OF CLUB LIGHTING IS GIVEN ON PAGES 50 AND 51.

REFERENCE SHOULD ALSO BE MADE TO THE EXAMPLES ON PAGES 66 AND 150.

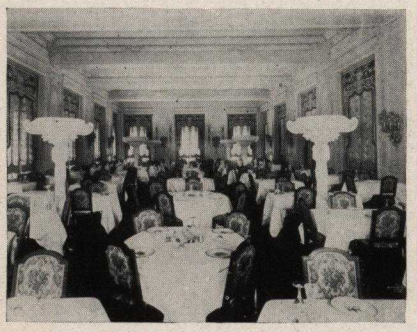
HOTELS

THE LIGHTING OF HOTELS IS DISCUSSED ON PAGE 52. HOTEL ROOMS LIGHTED WITH FIXTURES AND FLOOR PEDESTALS ARE ILLUSTRATED ON PAGES 66, 67, 82 AND 106.



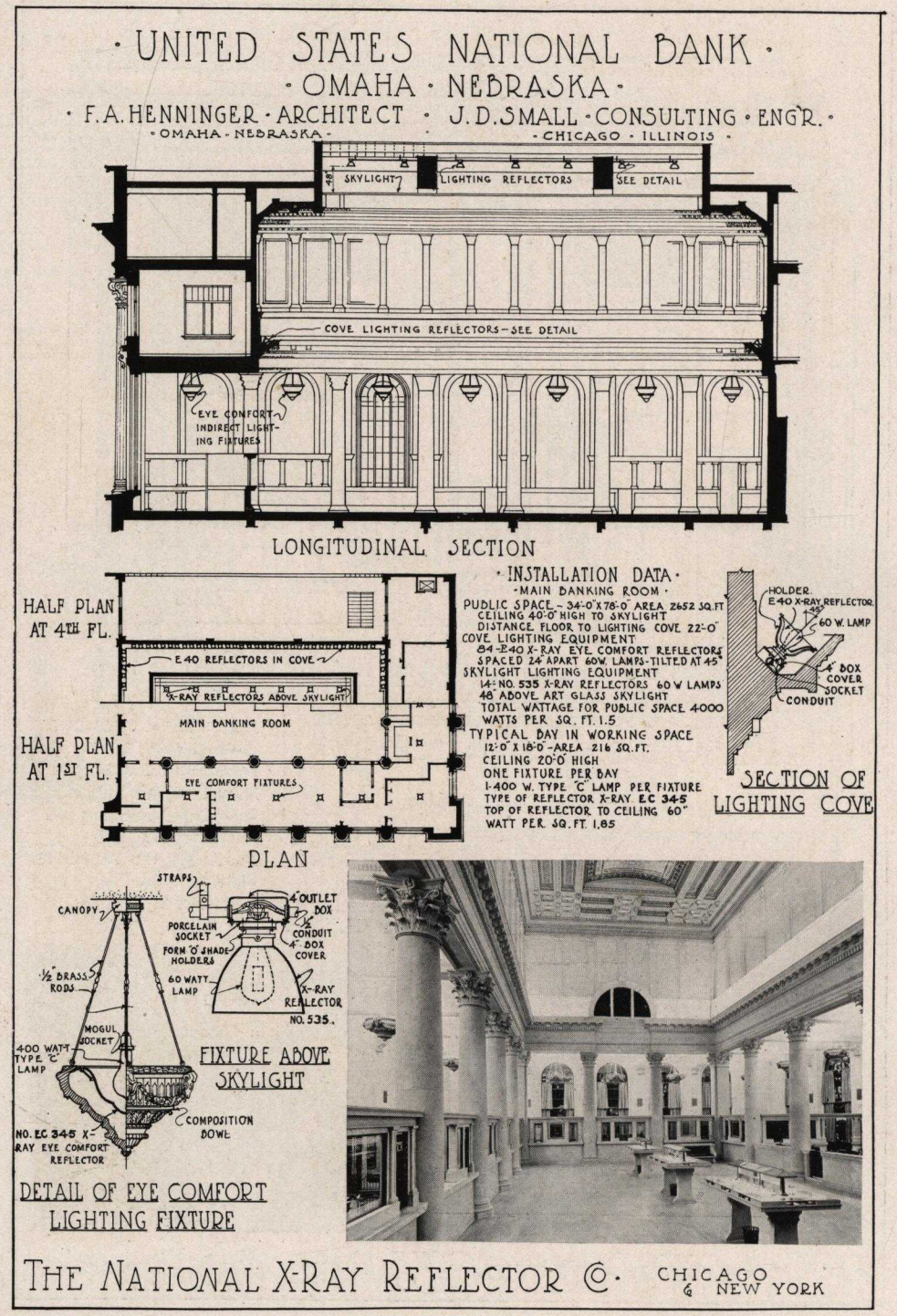
PART OF WEST-ELEVATION OF DINING-ROOM
SCALE ¼"-1'0"

SIZE OF ROOM 38'-0" × 95'-0"
CEILING HEIGHT 20'-0"
AREA OF ROOM 3610 SQ. FT.
X-RAY EYE COMFORT REFLECTOR IC-15
TOP OF REFLECTOR TO CEILING 12'-6"
NUMBER OF OUTLETS 8
MAZDA LAMPS PER PEDESTAL-4-200-WATT, CLEAR BULB.
WATTS PER SQ. FT.-1.78



THE-NATIONAL-X-RAY-REFLECTOR-CO.-236 W. JACKSON BLVD. CHICAGO-ILL.

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.



BANKS

THE LIGHTING OF BANKS WITH CEILING FIXTURES IS FULLY DESCRIBED ON PAGE 44.

LIGHTING FROM COLUMN CLUSTERS ON PAGE 97 AND FROM THE TOPS OF BANK PARTITIONS ON PAGE 92.

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

CHURCHES

THE LIGHTING OF CHURCHES IN GENERAL IS DESCRIBED ON PAGES 59 TO 61, ALSO PAGES 85 AND 86.

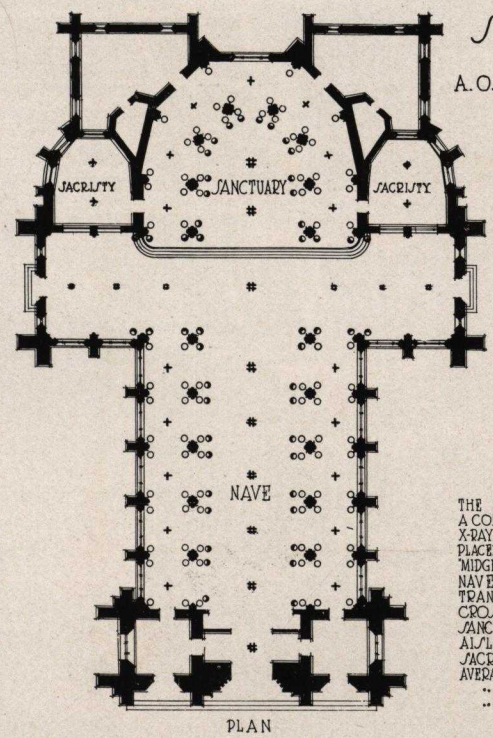
FOR THEIR ILLUMINATION WITHOUT FIXTURES, SEE PAGE 90.

FOR DIRECT LIGHTING IN THIS CLASS OF INTERIOR, SEE PAGE 158.

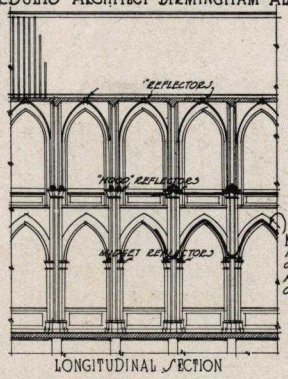
ST HELENA CATHEDRAL

HELENA • • MONTANA

A. O. Von HERDULIS • ARCHITECT • DIRMINGHAM ALABAMA



PLAN



LONGITUDINAL SECTION

• INSTALLATION DATA •

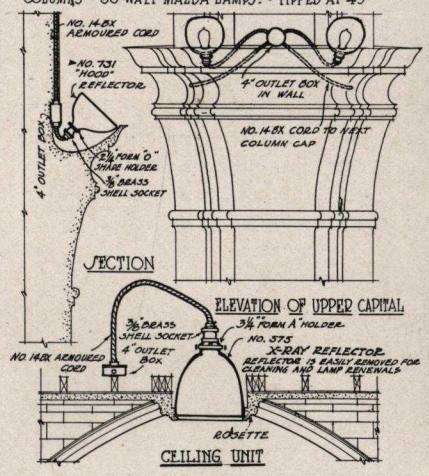
THE ILLUMINATION OF THIS CATHEDRAL IS ACCOMPLISHED BY A COMBINATION OF DIRECT AND INDIRECT LIGHTING SYSTEMS • • X-RAY "BEEHIVE" AND JUPITER DIRECT LIGHTING REFLECTORS ARE PLACED IN THE CEILINGS • • INDIRECT LIGHTING IS SUPPLIED BY "MIDGET" AND "HOOD" REFLECTORS IMBEDDED IN COLUMN CAPS •

NAVE • • • 32'-0" X 68'-0" CEILING HEIGHT 56'-0"
TRANCEPTS 32'-0" X 44'-0" " " "
CROSSING 32'-0" X 32'-0" " " "
SANCTUARY 60'-0" X 47'-0" " " "
AISLES 14'-0" WIDE • CEILING HEIGHT 26'-0" •
SACRISTIES 23'-0" X 24'-0" • CEILING HEIGHT 31'-0" •

AVERAGE WATTS PER SQ. FT FOR DIRECT • .37 AV. FOOT CANDLES 2.0
" " " " " " INDIRECT • .71 " " " 1.0
" " " " " " TOTAL 1.08 " " " 3.0

• DATA AND KEY TO PLAN •

* 15 "JUPITER" NO. 610 REFLECTORS IN MAIN CEILING • 200 WATT MAZDA LAMPS •
+ 22 "BEEHIVE" NO. 575 REFLECTORS IN AISLE CEILINGS AND SACRISTIES • 100 WATT MAZDA LAMPS
○ 94 "MIDGET" NO 510 REFLECTORS IN LOWER CAPS OF COLUMNS • 25 WATT TUBULAR MAZDA LAMPS.
● 30 "HOOD" NO. 731 REFLECTORS IN UPPER CAPS OF COLUMNS • 60 WATT MAZDA LAMPS. • TIPPED AT 45°



• THE NATIONAL X-RAY REFLECTOR Co. • CHICAGO & NEW YORK •

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

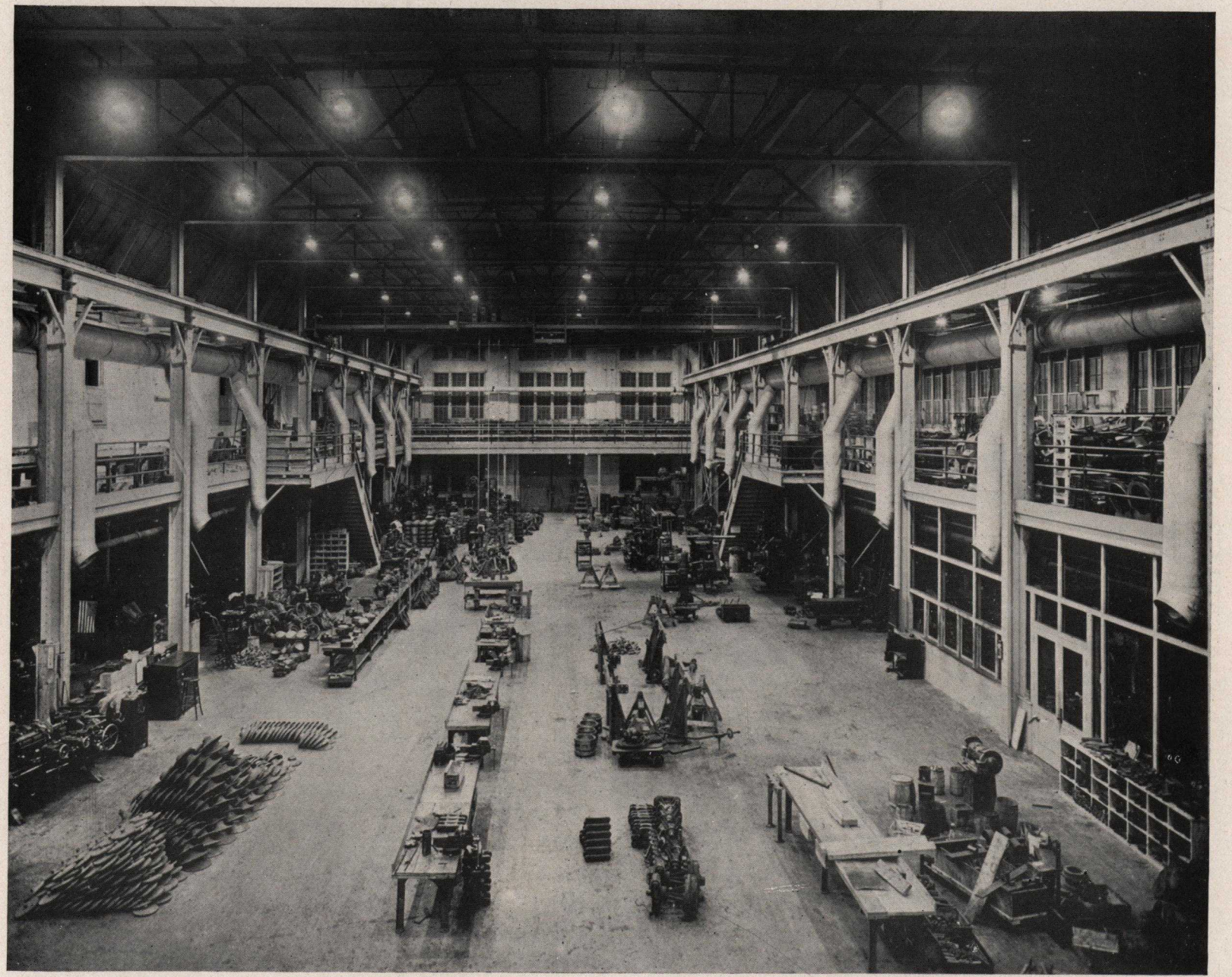


Fig. 203. Night view in the factory of the Pyle National Company, Chicago, Ill. F. E. Davidson, Architect. *See also page 156.*

VIII DIRECT LIGHTING

ITS GENERAL USES

THE X-Ray reflectors for direct lighting are built upon the same principle of concealing the lamp as was carried out for the indirect lighting equipment described in chapter IV.

This principle of illumination from concealed sources is correct, whether the lighting be by direct means or indirect methods. X-Ray direct lighting reflectors are so designed as to practically hide the lamp from view, thus shielding the brilliant filament from the eye.

The X-Ray system of direct lighting can be applied to the majority of interiors in which indirect illumination is not suitable—such as, factories, workrooms, power stations, printing plants, armories, gymnasiums, garages, swimming pools, etc.

The X-Ray direct lighting system possesses the following inherents characteristics:

1. *Correct design of the reflectors.*
2. *High efficiency of reflector.*
3. *Permanent efficiency of reflector.*
4. *Ease of maintenance.*

The reflector has two purposes to fulfill. The first purpose is to protect the eyes from the intense brilliancy of the lamp filament, and the second purpose is that of catching up the light that would otherwise fall upon the walls and ceiling and redirect it downward to the tables, benches, thus converting wasted light into useful light.

Both of these purposes should be accomplished by the same unit with little loss of light and in such a way that the resulting illumination is properly distributed and diffused. With the X-Ray reflector all of these advantages are combined.

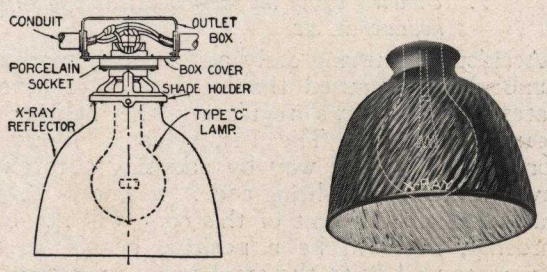


Fig. 204. Diagram and photograph of typical X-Ray industrial lighting reflector showing how the lamp is concealed from view.

EVILS OF GLARE AND INADEQUATE LIGHT

Glare is one of the worse enemies of personal efficiency. It creates eye strain, headaches and nervous irritability. Some efficiency men contend the glare from even a small 15 watt filament decreases the seeing efficiency of the eye 25%. It is generally recognized now that exposed light sources not only decrease the functions of the eye but leads to early nervous and physical fatigue, with constant irritation and liability to accidents.

Wrong lighting is not necessarily confined to dim lighting. Glaring light that strikes the employee's eye and the presence of strong shadows in the workroom are also wrong lighting conditions that result in loss to the manufacturer.

Fig. 205. Poor light and glare contribute to accidents.

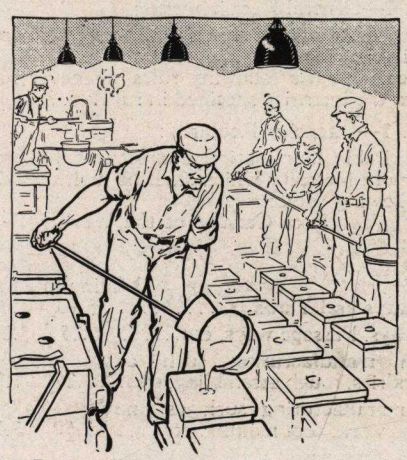


Fig. 206. Proper illumination makes work safe and easy.

The most common evils that result from glaring lamps and poor illumination are:

1. *Time is wasted.*
2. *Work is spoiled.*
3. *Preventable accidents occur.*
4. *Poor inspection; seconds are sent out as perfect samples.*
5. *Slowing up of the worker due to eye strain, headaches, etc.*

Accidents occurring daily and in such enormous numbers have caused the legislatures of several states to pass laws regulating the lighting of industrial plants. The Pennsylvania Industrial Board has led the way by adopting a carefully devised industrial lighting code. In poorly lighted plants the enforcement of this code will not be a hardship, but will be a positive benefit to the owners as well as to the employee. An extract of this lighting law is given below.

INDUSTRIAL LIGHTING LAW

The codes of lighting recently put into effect by the states of Pennsylvania, Wisconsin and New Jersey establish a standard to be used by owners and managers of industrial plants. In addition to the requirements for intensity of light there are rules which relate to the shading of lamps for the preventing of glare from units directly in the line of vision and to the distribution of light on the work to avoid shadows and sharp contrasts.

The important things to note in this connection is that the X-Ray direct lighting reflector exactly meets the requirements of this code. They are built to hide the lamp, thus preventing harmful and annoying glare. They are designed to give a broad flood of light and when properly installed provide a well distributed and even illumination for all parts of the working area.

THE PENNSYLVANIA CODE

Rule No. 1—General Requirements:

Working or traversed spaces in buildings or grounds shall be supplied during the time of use with artificial light in accordance with the following rules whenever natural light falls below the intensity specified in rule No. 2.

Rule No. 2—Intensity Required:

The desirable illumination intensity to be provided and the minimum intensity which shall be maintained are shown in the following table:

Foot Candles at the Work

	Minimum	Ordinarily Acceptable Practice
1: Roadways and Yards.....	.05	.05 to 0.25
2: Stairways, Passage ways, etc.....	.25	.25 to .50
3: Rough manufacturing such as foundries, rough assembling, etc..	1.25	1.25 to 2.50
4: Fine manufacturing such as fine lathe work, tool making, etc....	3.50	3.50 to 6
5: Special fine work such as watch making, engraving, etc.....	5	10 to 15

Uncertain cases and intermediate requirements are to be left to the judgment of the State's Industrial Board.

Rule No. 3—Shading of Lamps:

Glare either from the lamps or unduly bright surfaces produces eye strain and increases accident hazard.

Exposed bare lamps shall not be used except when they are out of the ordinary line of vision. Lamps should be suitably fitted to minimize glare.

Rule No. 4—Distribution of Light on the Work:

Lamps should so be arranged so as to secure a good distribution of light on the work, avoiding objectionable shadows and sharp contrasts of intensity.

Rule No. 5—Emergency Lighting:

Emergency lighting shall be provided in all work spaces, aisles, stairways, passage ways and exits. Such lights shall be so arranged as to insure their reliable operation when through accident or other cause the regular lighting is extinguished.

Rule No. 6 Switching and Controlling Apparatus:

Switching and controlling apparatus shall be so placed that at least pilot or night lights may be turned on at the main point of entrance.

ADVANTAGES OF GOOD LIGHTING IN SHOPS WITH X-RAY REFLECTORS

Five definite profits may be easily had by modernizing direct lighting in shops using X-Ray reflectors.

1. *Increased output.*
2. *Less spoilage.*
3. *Fewer accidents.*
4. *Better working conditions.*
5. *Better light for less money.*

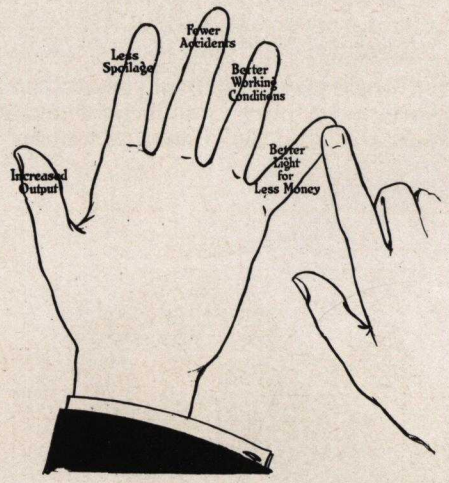


Fig. 207. The five advantages gained by using X-Ray direct lighting reflectors.

Increased Output

The consulting engineers who put the lighting in the Weaving Department of the Seymour Woolen Mills, Seymour, Indiana, afterwards wrote —"The efficiency of this department has been

increased about 20% by reason of the new installation. The loom operators are very much pleased with the illumination. There is absence of eye strain and the work can be handled as readily after dark as in the day time. As the operators are on piece work basis, this has enabled them not only to increase the capacity of their department, but also has resulted in increased wages. The owner of this plant states that the only trouble he has now, is that the Weaving Department has most every day some time in which they have to wait for the rest of the plant to catch up."

Less Spoilage

The United States Census Department figures show that in 1910 the 268,491 manufacturing plants in the country turned out over $20,000,000,000 worth of finished products. Spoilage for that year amounted to $150,000,000—*75%* occurred under artificial light of which 20% was caused by poor lighting. These staggering figures mean $30,000,000 worth of seconds in one year traceable directly to poor lighting, or $100,000 per day.

Fewer Accidents

Dr. Tolman, director of the American Museum of Safety says—"Considering proper illumination as a factor of safety, it is safe to say that the adequate lighting of shops and factories would probably prevent 25% of the avoidable accidents in industry."

The diagram below shows graphically how the increase in the number of accidents takes place in the shorter winter days when a greater proportion of the work is done under artificial light. If accidents increase as the number of artificial lights increase, then artificial illumination must have a very direct bearing on accident prevention. The nearer to day light the artificial lighting is, the fewer will be the accidents.

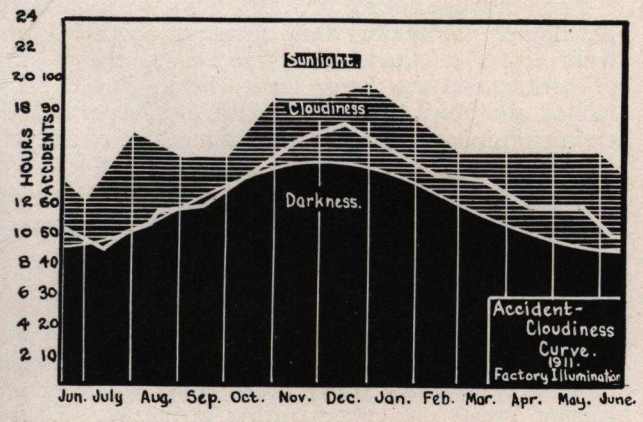


Fig. 208. Chart showing the average hours per day of sunshine, cloudiness and darkness for each month of the year, and the seasonable distribution for accidents in industrial plants. The broken white line is the accident curve.

Better Working Conditions

The following is quoted from the U. S. Department of the Interior Bulletin:

"Careful attention should be given to the proper lighting of any industrial establishment. The intimate relation between good illumination and the efficiency, safety and bodily welfare of the employees should be considered and steps taken to see that good illumination is afforded all workers. For years many have been working in the dark, yet none would venture to say that a workman could work to his full capacity unless his work was adequately and properly illuminated."

Better Lighting for Less Money

The high efficiency and permanent qualities of X-Ray direct lighting reflectors makes them the most desirable for industrial and commercial lighting purposes. Because of the high efficiency of the X-Ray reflector the greatest economy results from their use.

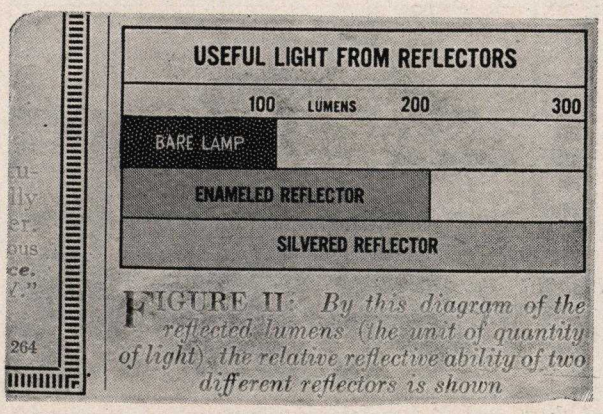


Fig. 209. Relative reflecting qualities of various types of reflectors.

The following is quoted verbatim from an article accompanying this chart published in December, 1915, issue of Factory Magazine. "Tests show that a deep bowl enamel steel reflector of the type commonly seen in factories having the general system of direct lighting, doubles the amount of useful light from a 60 watt Tungsten incandescent at a suspension of 8 feet above the working plane.

"Another type of reflector almost indentical in design but having a silvered reflecting surface gave approximately three times the quantity of useful light as the bare bulb, over 50% more than the reflector with the enamel reflecting surface."

MAINTENANCE

There are two causes for loss in efficiency of direct lighting installations. First, the accumulation of dirt on the reflectors and lamps; second, the blackening of the interior of the lamp bulbs when they are burned beyond their rated light.

It is the ordinary practice to install a lighting installation so that sufficient illumination is obtained under normal conditions—that is, when the lamp is new and clean and with reflector surfaces clean. As soon as dirt and dust begins to accumulate upon the lighting equipment, the effective illumination is reduced at once. The relationship between time in weeks and the percentage of the original efficiency of the lighting installation is shown graphically below.

The time between cleanings of the reflector equipment will depend upon local conditions. The loss due to poor illumination can be measured in two ways—the loss of light may be figured in power consumed but not used effectively and the loss of efficiency of workmen due to poor lighting. The latter, although it cannot be figured in dollars and cents, is by far the greater loss in most cases.

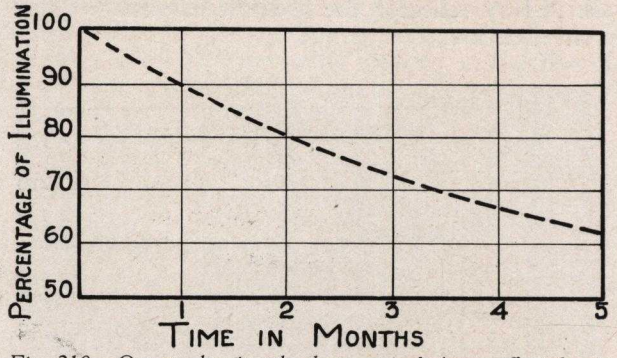


Fig. 210. Curves showing the decrease in lighting effect due to accumulation of dirt and dust on lamps and reflectors.

Various tests have been made to determine the loss of lighting effect due to the accumulation of dust and dirt on the equipment. Ten percent. per month is an average that is given by several authorities. Many installations will show a less loss than this and others, of course, a much greater loss. If a regular schedule is adopted and the lamps and reflectors are thoroughly cleaned every two months, the resultant average illumination will be fairly high.

In many office buildings and manufacturing plants the cleaning and renewing of lamps and lighting equipment is performed at regular intervals, just as is the case with the washing of windows or replacing of worn out machine parts. The most satisfactory method of taking care of maintenance is, of course, on a regular schedule, since it means a high standard of service.

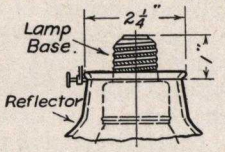


Fig. 211. "O" 2¼ in.

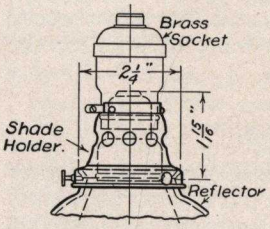


Fig. 212. "H" 2¼ in.

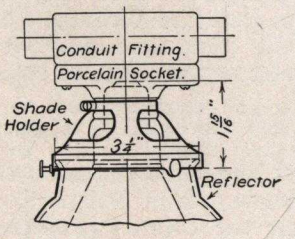


Fig. 213. "A" 3¼ in.

Shade holder positions.

SHADE HOLDERS

To avoid trouble in installing reflectors and to insure that the lamp is held in the proper position in the reflector, follow the suggestions given below.

X-Ray reflectors are made with necks of standard sizes. Regular stock shade holders can be used. The types mentioned will fit the various kinds of brass shell sockets and conduit fittings that are carried by electrical dealers and jobbers.

Where porcelain receptacles are used, care should be taken to procure porcelains with the shade holder groove.

The correct relation of reflector and shade holder are shown by the accompanying figures.

Note that the Form "O", 2¼ inches, is a low or flat holder maintaining a dimension of about 1 inch from center of shade holder screws to the point of contact of the lamp base. Form "H", 2¼ inches, and Form "A", 3¼ inches, are deeper holders maintaining a corresponding dimension of about 1 15-16 inches.

Figures 212 and 213 show the adaptation of holders to brass shell and porcelain sockets respectively.

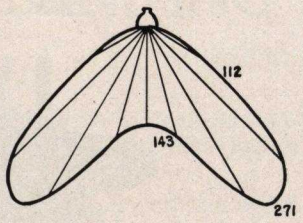
X-RAY REFLECTORS CLASSIFIED

X-Ray reflectors are designed for various classes of service, some are distributing, some are concentrating, some semi-concentrating in nature. Each meets a particular requirement, and for a definite size of lamp. Perfect lighting will result only when the proper lamp is used with the correct reflector.

X-RAY REFLECTORS FOR DIRECT LIGHTING

No. 535

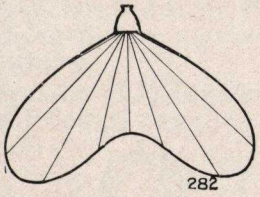
Lamp 75-watt Mazda "C."
Diameter 5¾ inches, *height* 5⅛ inches.
Holder 2¼ inches, Form "H."



Distribution of light with 75-watt lamp.

No. 570

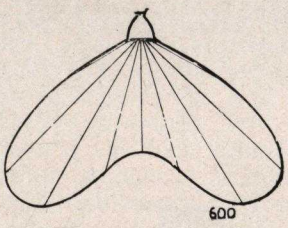
Lamp 100-watt Mazda "C."
Diameter 7⅞ inches, *height* 6⅞ inches.
Holder 3¼ inches, Form "A."



Distribution of light with 100-watt lamp.

No. 575

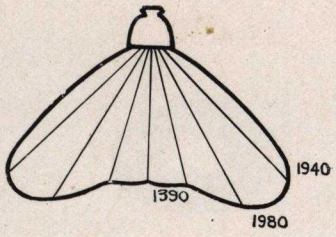
Lamp 200-watt Mazda "C."
Diameter 9⅜ inches, *height* 8 inches.
Holder 3¼ inches, Form "A."



Distribution of light with 200-watt lamp.

No. 580

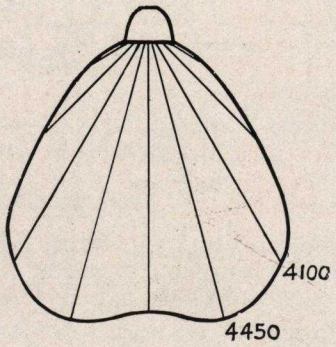
Lamp 300, 400, or 500-watt Mazda "C."
Diameter 11⅞ inches, *height* 9⅜ inches.
Holder special, supplied with reflector.



Distribution of light with 500-watt lamp.

"Jumbo Unit"
No. 54

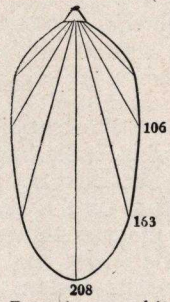
Lamp 1,000-watt Mazda "C."
Diameter 16½ inches, *height* 13⅜ inches.
Holder, special.



Distribution of light with 1,000-watt lamp.

No. 696

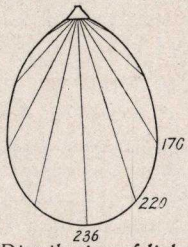
Lamps 25, 40, 50, 60-watt Mazda "B"; 75-watt Mazda "C."
Diameter 8 inches, *height* 5 inches.
Holder 2¼ inches, Form "O."



Distribution of light with 40-watt lamp.

No. 700

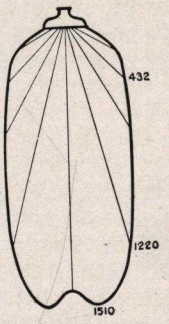
Lamps 60 and 100-watt Mazda "B" and "C."
Diameter 10 inches, *height* 5½ inches.
Holder 2¼ inches, Form "O" for 60-watt lamps. Form "H" for 100-watt lamps.



Distribution of light with 60-watt lamp.

No. 710

Lamps 200-watt Mazda "C."
Diameter 11½ inches, *height* 6¾ inches.
Holder 3¼ inches, Form "A."



Distribution of light with 200-watt lamp.

FITTINGS FOR X-RAY DIRECT LIGHTING REFLECTORS

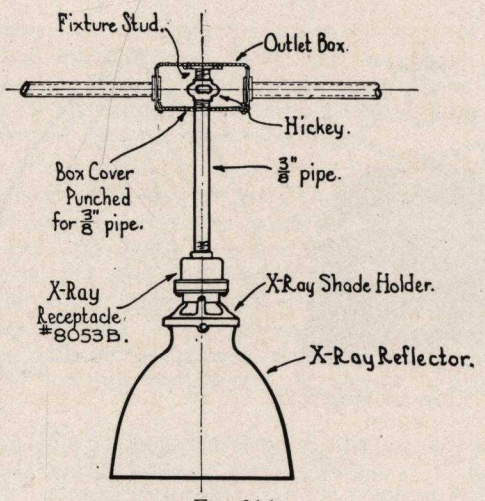


Fig. 214

Stem Suspension

Above illustration shows a correct method for suspending direct lighting reflectors from the standard outlet box by means of a short stem. No insulating joint is necessary if the unit is installed in the manner shown, providing the No. 14 wires from the outlet box are carried down through the pipe to the socket. For lamps above 200 watts asbestos slow burning wire should be used from the socket to the outlet box. The 3/8-inch pipe supporting the socket should be at least 6 inches long. This method of suspension can be used for reflectors 535, 570, 575, and 580.

Outlet Box Unit

Figure 215 shows a complete box cover unit consisting of reflector, shade, holder receptacle, and box cover which will fit the standard round outlet box having lugs. This unit is made up of the fittings shown on this page. It is compact, economical, and easily installed. It is especially suitable for reflector 535 when used with the 40-50-, 60- or 75-watt lamp. When larger lamps are used the stem suspension should be employed.

Receptacle
No. 8053B

Pig Tail Receptacle
No. 8117

Clamping Receptacle
No. 8118

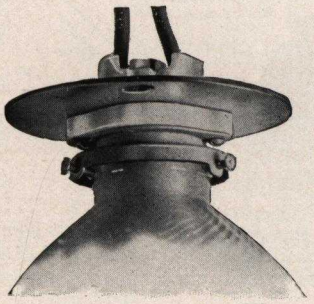
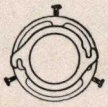


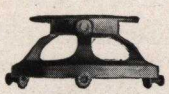
Fig. 215



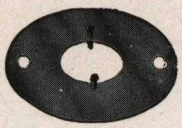
Top view of the three Special X-Ray Reflector Holders showing method of holding in place by two screws which hold X-Ray receptacle in fitting.

Form "O"—2¼-inch Holder
No. 10100

Form "H"—2¼-inch Holder
No. 10127



Form "A"—3¼-inch Holder
No. 10128



Round Box Covers

No. 10145, 3-inch Cover
No. 10146, 4-inch Cover

Form "A"—3¼-inch Holder
No. 10219

For porcelain receptacles requiring a weatherproof size holder.

IX PLANNING DIRECT LIGHTING

METHODS OF FIGURING

X-RAY reflectors have a wide adaptability. They can be used in every place where indoor direct lighting is required.

X-Ray reflectors find their greatest application in the illumination of industrial and commercial interiors as for instance factories, workrooms, mills, foundries and power plants. They are the most efficient reflectors also for printing plants, public markets, armories, gymnasiums, swimming pools, tennis courts, hand-ball courts, bowling alleys, billiard tables, for sky lighting, letter cases, rug racks, bulletin boards and stage lighting.

Many of the above applications of X-Ray direct lighting are described in the following pages.

Laying Out The Lighting

Just as the layout and installation of the power plant requires the expert knowledge of a competent steam engineer, so does lighting with its far reaching influence on production require the knowledge of the lighting man. The power engineer tells what size boiler will be needed, what coal should be burned and the best place for shafting and belting. Likewise, the size and type of lamp to use, how to space the units, what reflectors to employ, how to secure maximum diffusion and the best light for the work so that the maximum amount of illumination properly distributed and with correct intensity and colors for efficient manufacturing should be carefully worked out.

Electric light is energy and must be conserved just as steam and water power if the most efficient results are to be obtained and at the lowest cost. X-Ray reflectors when properly installed provide the greatest economy in industrial and commercial lighting.

Calculating Wattage Required

Three general methods for the calculating of X-Ray lighting are described, namely:

(1) The watt per square foot method.
(2) The lumen method.
(3) The point by point method.

THE WATT PER SQUARE METHOD

Direct lighting installations classify themselves into three divisions, usually known as general, local and local-general lighting, in contrast to indirect lighting the very nature of which makes it essentially a system of general illumination.

General Illumination

By general illumination, we mean a fairly uniform illumination throughout the given area which is secured by means of an overhead lighting system.

A simple method of making calculations for illumination by incandescent lamps with X-Ray direct lighting reflectors is as follows:

(1) *Selection of Unit Area.* Select a typical bay or area which may be considered the unit area for purposes of lighting calculations. This area in most cases will be one of the squares into which the building is naturally divided architecturally by columns, posts, ceiling beams, etc.

(2) *Wattage Required.* The wattage required to properly illuminate this unit area depends upon the character of work done under the light, and the use to which the room or building is put. The values of watts per square foot for various classes of service are to be found in Table No. 3. By multiplying these values by the number of square feet in the unit area, the total wattage for the unit area is obtained.

(3) *Number of Lamps.* This value of total wattage determines the number of lamps of any given size to be used for the unit area.

(4) *Spacing of Units.* Spacing and height of suspension of the lighting unit depends upon the degree of diffusion and uniformity of illumination desired. In general, the greater the number of units and the closer the spacing, the less intense the shadows will be and the more uniform the illumination.

(5) *Selection of Reflector and Hanging Height.* The selection of the proper reflector for a certain unit area is governed by the dimensions of the space—length, width and height. If this area is quite large as in cases where general illumination is required, the distributing type or Beehive Type of X-Ray reflector should be used. When a space is more limited as for local-general illumination concentrating or semi-concentrating reflectors should be used and may be more desirable. The hanging height also depends upon the dimensions of the unit area to a large extent, but in addition to this, it depends upon the height of the work-

ing plane above the floor and the type of reflectors to be used. The choice of reflectors and hanging heights are mutually dependent upon each other. In order to assist in making the proper selection the following rules are given:

Distributing Reflector. For uniform lighting, these reflectors should be spaced about 1½ times the height of the suspension above the working plane.

Semi-Concentrating Reflectors. For uniform lighting, these reflectors should be placed a distance about equal to the height of suspension above the working plane.

Concentrating Reflectors. For uniform lighting the reflectors should be placed about .6 times the height of suspension above the working plane.

On page 119 are given the various X-Ray direct lighting reflectors classified according to wattage capacity and type of light distribution.

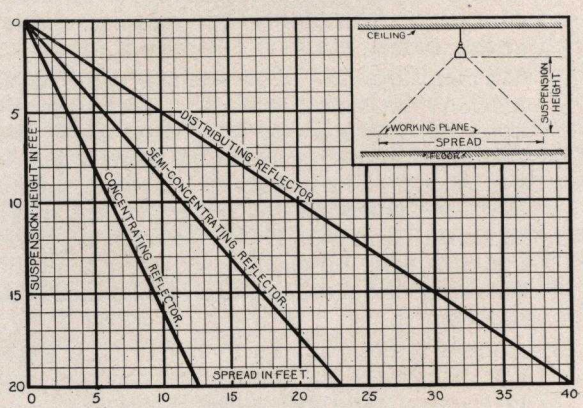


Fig. 216. Spacing chart for X-Ray direct lighting reflector units.

The chart in Figure 216 shows for various suspension heights the maximum size of circular area which can be uniformly illuminated from a single lighting unit.

For instance, it is seen that for the distributing reflectors the units will cover a circle whose diameter is twice the height of the suspension.

Local Illumination

In local illumination the lighting is accomplished by means of a lamp and reflector hanging on a drop cord or bracket, causing a strong light to fall upon the work and leaving the rest of the room in comparative darkness. Local lighting illuminates a very limited area and should be used only to supplement a general lighting system. In fact, good practice discourages the use of local lighting except where extremely fine work requires an unusually high intensity or whenever general lighting will not penetrate. The general tendency on the part of workmen to use too large a lamp for local lighting should be guarded against from the economy standpoint as well as ocular comfort.

Ordinarily, no computations are necessary in planning the requirements for local lighting. Never figure on local lighting only, because when used to a large extent, it is most uneconomical in the initial

TABLE NO. 3

Illumination in Foot Candles and Wattage per Square Foot for Various Requirements.

Kind of Interior	Foot Candles	Watts per Sq. Ft.*
Armories—Drill Hall	3	.45
Art Galleries (Walls)	5	.75
Auditoriums	3	.45
Auto Show Rooms	5	.75
Billiard Rooms	2	.30
Billiard Tables	5	.75
Bowling Alleys	2	.30
Pins	10	1.60
Car Barns	2	.30
Carpenter Shops	4	.65
Church	3	.45
Dance Hall	3	.45
Drafting Room	4	.65
Drafting Room Tables	10	1.60
Engraving	10	1.60
Factory general illumination (see local lighting)	2½	.40
General (no local lighting)	6	.90
Local lighting (bench work)	6	.90
Foundries	4	.65
Freight Houses	2	.30
Garages	2	.30
Gymnasiums	3	.45
Knitting Mills	5	.75
Laundries	4	.65
Laboratories	3½	.55
Machine Shops	(see factory)	
Offices	4	.65
Operating Tables	15	2.30
Pattern Shops	4	.65
Power Houses	3	.45
Press Rooms	4	.65
Residences—pantries and kitchens	2	.30
Laundries	2½	.40
Furnace Rooms	1	.15
Restaurants	3	.45
Rug Racks	15	2.30
Sewing Rooms—light goods	5	.75
Dark goods	10	1.60
Skating Rinks	2	.30
Spinning Rooms	5	.75
Stables	1	.15
Stock Rooms	2	.30
Stores	5	.75
Store Rooms	1	.15
Swimming Pools	2½	.40
Telephone Exchanges	3	.45
Train sheds	2	.30
Type Setting	8	1.30
Warehouses	1½	.25
Weaving	6	.90
Work Rooms	(see factory)	

*For small rooms increase the values of watts per square foot because of the absorption of the walls, etc. For very large rooms these values may be decreased.

cost of installation, the cost of energy, the cost of maintenance and least satisfactory from the practical view point.

Local-General Illumination or Group Lighting

As the name signifies, local-general illumination is a sort of compromise between the two methods of lighting. The lighting of the work is accomplished by means of local lights in the proper position, but these are suspended at such height and in such grouping as to give a fairly good general illumination also.

This system of lighting works out very good for the lighting of print shops and in the textile industry. In these places it is essential that the lighting units be arranged with particular attention to the machines and the operators, and at the same time there must be no dark nooks or corners or moving parts of machines in deep shadow.

Calculations are made similarly as for general illumination with the exception that a large number of small units will ordinarily be used rather than a fewer number of large ones.

Example

Suppose we desire to lay out the lighting for the assembling room of a factory building in which small machines are built. The dimensions of this room are 200 by 104 feet with a 12-foot ceiling.

The floor space is divided into 32 bays, each 25 by 26 feet in area, by columns and ceiling beams. The working plane may be considered to be 42 feet above the floor.

Let us assume that the character of most of the assembling work is such that an intense general illumination will suffice and that additional local illumination will be required in but few instances. The decision as to whether a general system of lighting will meet the requirements must be based on careful observation and study of the work carried on.

The first step is to select our unit area which, in this case, quite naturally is the bay. Referring to Table No. 3, we find that for machine work, we should use a wattage of .9 watts per square foot. The total wattage required then for each bay is 650 times .9 which equals 585 watts.

This means we must use either 1 500-watt lamp or 4 150-watt lamps per bay. A single unit per bay is out of the question because the long dimension 26 feet greatly exceeds 1½ times the suspension height. The suspension height, 8 feet 6 inches times 1½, equals 12 feet 9 inches.

Hence, we must use 4 units per bay. From page 119, we find that the distributing type of 150-watt reflector is the number 570, which must be used with the Form "A," 3¼ inches, shade holder in order that the lamp be in correct relationship with the reflector. The reflector units should be placed as closely to the ceiling as possible, suspended on a short stem, see page 120.

THE LUMEN METHOD

This method of making calculations was carefully described on page 33 of the indirect lighting section. The procedure in making calculations for X-Ray direct lighting by the lumen method is practically the same as that used for indirect lighting. With direct lighting, however, the values for utilization efficiency are higher than in the case of the indirect lighting.

Example

It is required to illuminate a machine shop in which both bench and machine work are done and in which the nature of the work is such that no local light would be required. Obviously, the best system of lighting for this shop is general illumination of correct intensity.

Dimensions of shop 40 by 96 feet.
Ceiling height 12 feet 6 inches.
Area subdivided into 8 20 by 24-foot bays.
Working plane 4 feet above the floor.
Walls medium color.

(1) *Selection of Unit Area.* Consider a typical bay 20 by 24 feet as the unit area, 480 square feet.

(2) *Illumination Required.* Table No. 3 indicates that for a machine shop the intensity of 6-foot candles is required.

(3) *Effective Lumens.* Multiply the number of square feet in the unit area by the number of foot candles required. The product is the effective lumens. Therefore, 480 times 6 equals 2880. The effective lumens required for the unit area above.

(4) *Efficiency of Utilization.* We find in Table No. 4 the efficiency of utilization for medium walls is 50%.

(5) *Number and Size of Lamp.* The number of lighting units depends upon the character of the lighting required. For instance, in a machine shop where little or no local lighting is used a uniformly diffused illumination is necessary, whereas, in the shipping room or warehouse uniform illumination is not essential.

The closer the units are together, the less chance there will be of shadows and the more uniform lighting result. Fig. 216 gives the maximum dimension of the area which can be practically uniformally illuminated from one unit of various heights of suspension. For the machine shop, therefore, this chart should be used in determining and locating the number of units for the unit area. In the case of the shipping room or warehouse the single lighting unit in the center of the square or bay is usually sufficient. It is apparent that the lighting unit should be placed as near the ceiling as possible. In this case the lower edge of the reflector will be about 1 foot from the ceiling, which will make the height of suspension above the working plane equal to 7 feet 6 inches. Fig. 216 shows that a single lamp at the ceiling in the most distributing reflector will not spread over the area to be lighted, hence 4 units should be employed and placed symmetrically on the ceiling.

The size of lamp can now be determined by referring to Fig. 217 which gives the effective lumens corresponding to various efficiency of utilization values for the different lamp sizes.

In this instance, each lamp must deliver ¼ of 2880 or 720 effective lumens at 50% efficiency of utilization.

By referring to Fig. 217, we find that the 100-watt lamp most nearly corresponds with this requirement.

(6) *Selection of Reflector.* Page 119 shows the X-Ray Direct Lighting Reflectors for various lamp sizes. We find that the proper distributing reflector for the 100-watt lamp is the No. 570.

TABLE No. 4

Color of Walls	Efficiency of Utilization
Light	60 percent
Medium	50 percent
Dark	40 percent

The color of the ceiling has no effect on the efficiency of utilization with direct lighting employing opaque reflectors.

In areas having a minimum dimension over 3½ times the ceiling height, the efficiency is not affected by the color of the walls, under these conditions the efficiency of utilization varies from 60 percent to 70 percent.

LAMP DATA

The information given in the table of Figure 217 includes the principle Mazda "B" and Mazda "C" lamp, those most frequently used for standard lighting service. Only those lamps of the 110-125 voltage class are included. The data covering the dimensions of the bulbs, the values of total lumens, and size of base were taken from catalogs of lamp manufacturers.

The values of lumens under the headings 40, 50, and 60% are the number of lumens effective or usable at corresponding efficiencies of utilization.

Lamps designated for burning in any position can be employed horizontally, tip up, tip down, or at an angle. Those designated for tip down burning should normally be burned in that position only. Mazda "C" lamps of 200 watts and above can be obtained when specially ordered for tip up burning.

LUMEN DATA FOR MAZDA LAMPS.

VOLTAGE CLASS: 110 TO 125 VOLT.

RATED WATTS.	DIAMETER OF BULB INCHES.	OVERALL LENGTH INCHES.	LIGHT CENTER LENGTH INCHES.	BASE.	LUMENS PER WATT	LUMENS. TOTAL	40%	50%	60%	POSITION OF BURNING.
MAZDA "B" LAMPS.										
10	2 1/8"	4 7/8"	2 7/8"	MED. SCR.	7.52	75	30	37	45	ANY
15	2 1/8"	4 7/8"	"	" "	8.32	125	50	62	75	"
25	2 3/8"	5 1/4"	3 1/4"	" "	8.91	223	89	111	134	"
40	2 3/8"	5 1/4"	"	" "	9.24	369	147	184	221	"
50	2 3/8"	5 1/4"	"	" "	9.45	473	189	236	283	"
60	2 5/8"	5 1/2"	3 7/16"	" "	9.59	575	230	287	345	"
100	3 1/4"	7 7/8"	5 3/16"	" "	9.97	997	399	498	598	"
MAZDA "C" LAMPS.										
75	2 3/4"	6 1/8"	4 5/16"	MED. SCR.	11.53	865	346	432	519	ANY
100	3 1/8"	7 1/8"	5 3/16"	" "	12.57	1257	503	628	754	"
150	3 1/8"	7 1/8"	5 3/16"	" "	13.66	2049	820	1024	1229	"
200	3 3/4"	8 3/8"	6"	" "	14.61	2922	1169	1461	1753	TIP DOWN
300	4 3/8"	9 3/4"	7"	MOG. SCR.	16.11	4833	1933	2416	2899	" "
400	5"	10"	7"	" "	16.76	6704	2682	3352	4023	" "
500	5"	10"	7"	" "	17.45	8727	3490	4362	5235	" "
750	6 1/2"	13 3/8"	9 1/2"	" "	18.48	13860	5544	6930	8316	" "
1000	6 1/2"	13 3/8"	9 1/2"	" "	19.33	19330	7732	9665	11598	" "

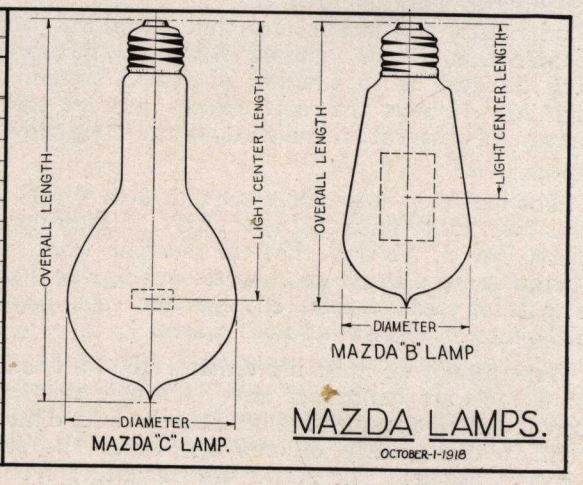
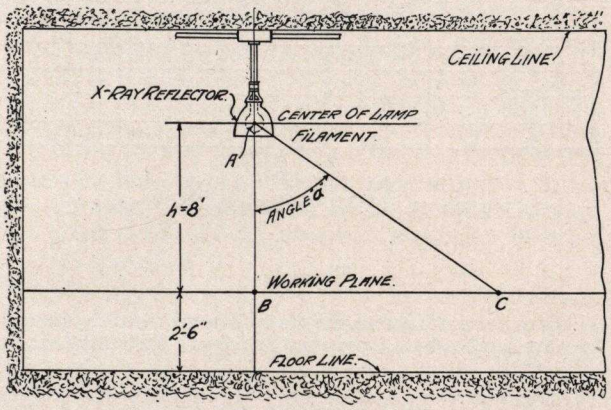


Fig. 217. Dimensions and lumen data for Mazda "B" and Mazda "C" lamps.

THE POINT-BY-POINT METHOD

This method of calculating the horizontal illumination from the lighting unit is not used extensively for general determinations. It is a laborious method and does not take into account absorption due to walls, surrounding objects, etc.



Fig, 218

The intensities in foot-candles are figured directly from the light distribution curve of the unit. Candlepower values of the curve are reduced to foot-candles by dividing by the square of the distance from the lamp to the point on the working plane. But this foot-candle value is not horizontal illumination. It is illumination in a plane perpendicular or normal to the direction from which the light is coming. To convert the foot-candle value to horizontal illumination, it is multiplied by the cosine of the angle between the vertical line through the lamp and the line of the direction of the light ray under consideration. (See figure 218).

A simple formula that will assist in making calculations by the Point-by-Point Method is as follows:

$$\mathbf{I} = \frac{\mathbf{cp}}{\mathbf{h^2}} (\cos^3 \mathbf{a})$$

in which

I = horizontal illumination at the point under consideration.

cp = candlepower value from the distribution curve of the unit in the direction AC.

h = distance of plane below the center of the lamp.

a = angle as shown in figure 218.

A table of values for ($\cos^3 a$) is given on Page 239.

Example

Determine the horizontal illumination on a working plane 6 feet from a unit consisting of one No. 535 X-Ray Reflector, with a 75-watt Mazda "C" lamp.

Candle power values at different angles for this unit are as follows:

Degrees	Candle Power
0	125
5	126
15	143
25	207
35	271
45	239
55	112
65	52

By applying the formula above and by plotting the results in graphical form we obtain the curve of foot-candle values given in the figure below.

When more than one unit is used, the foot-candle curves over-lap and the resultant foot-candle values are the summation of all of the over-lapping values.

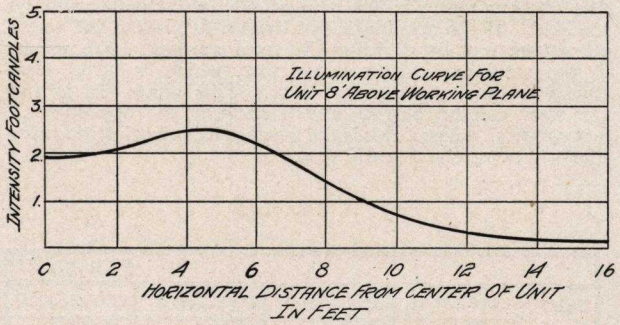


Fig. 219. Curve of lighting intensities.

ILLUMINATION CHARTS

(See Next Page)

For the various standard lamp sizes the tables in Figures 220 and 221, give average foot candle intensities obtainable on the working plane at various spacings. The wattage consumption in watts per square foot is also shown.

All the values in these tables are based upon an efficiency of utilization of 50%.

These charts should be used in connection with chart given in Figure 216 which shows the size of circular areas that can properly be covered from a single outlet from various suspension heights.

The increased efficiency or light giving power of the large sized lamps over those of smaller wattage is brought out in these tables. For instance in a given area to obtain 4 foot candles using 100 watt lamps .64 watts per square foot are necessary. Whereas, using 400 watt lamps only .48 watts per square foot are required. The specific conditions of the installation will, however, determine the size of lamp that is to be used.

The working of these charts is best illustrated by a few examples.

Example

As ume an area 48x48 feet to be illuminated to an average intensity of 5 foot candles. What size of lamp will be required? The area is divided by posts into 4 equal spaces each 24x24 feet, we can then take this smaller area as a basis for calculations.

Find the 5 foot candle value in the column at the left of the chart. Now, in the horizontal line opposite 5 foot candles the values are given for the spacing and watts per square foot for each lamp size. Let us assume that one lamp is to be used for the 24x24 foot space, the spacing that most nearly corresponds with the size of the area is given as 26 feet under the 400 watt lamp. The 400 watt lamp is the size to be used to give the illumination desired.

Example

Given an area 30x60 feet lighted by 8 units consisting of X-Ray reflectors with 150 watt Mazda "C" lamps what illumination in foot candles will be received?

If the units are spaced symmetrically, say 15 feet apart, this spacing value indicates that 4.5 foot candles will be received. If the spacing is not known determine the watts per square foot by dividing the total wattage, 1200 watts, by the total area, 1800 square feet, which in this case equals .66 watts per square foot. This value lies in the 150 watt column and on the horizontal line opposite 4.5 foot candles. Hence, this is the average illumination intensity that will be received in the area.

FOR MAZDA "B" LAMPS.

Foot Candles	25W. LAMP.		40W. LAMP.		50W. LAMP.		60W. LAMP.		100W. LAMP.	
	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing
.25	.056	21'-0"	.055	27'-0"	.054	31'-0"	.053	34'-0"	.051	45'-0"
.50	.112	15'-0"	.109	19'-6"	.107	21'-6"	.105	24'-0"	.101	32'-0"
.75	.17	12'-6"	.16	16'-0"	.16	18'-0"	.15	19'-6"	.15	26'-0"
1.00	.22	11'-0"	.22	13'-6"	.21	15'-6"	.21	17'-0"	.20	22'-6"
1.50	.36	8'-6"	.32	11'-0"	.32	12'-6"	.31	14'-0"	.30	18'-6"
2.00	.45	7'-6"	.44	9'-6"	.43	11'-0"	.42	12'-0"	.41	16-0
2.50	.56	6'-6"	.54	8'-6"	.53	9'-6"	.52	11'-0"	.50	14'-0"
3.00	.68	6'-0"	.66	8'-0"	.64	9'-0"	.63	10'-0"	.61	13-0"
3.50	.78	5'-6"	.76	7'-6"	.74	8'-0"	.73	9'-0"	.70	12'-0"
								October 1-1918		

Fig. 221. This chart for Mazda "B" Lamps serves the same purpose as Fig. 220 for Mazda "C" Lamps.

Example

How many watts per square foot will be required to produce 2.5 watt candles in a given interior using a 200 watt Mazda "C" lamp?

This can be read directly from the chart at the intersection of the horizontal line opposite 2.5 foot candles and the vertical line below 200 watt lamp. We find that .35 watts per square foot is the required wattage consumption to give the foot candles desired.

FOR MAZDA "C" LAMPS.

Foot Candles	75 W. LAMP.		100 W. LAMP.		150 W. LAMP.		200 W. LAMP.		300 W. LAMP.		400 W. LAMP.		500 W. LAMP.		750 W. LAMP.		1000 W. LAMP.	
	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing	Watts Sq. Ft.	Spacing
.5																		
1.0"	.17	20'-0"	.16	25'-0"	.15	32'-0"												
1.5	.26	17'-0"	.24	20'-0"	.22	26'-0"	.21	30'-0"										
2.0	.35	15'-0"	.32	17'-6"	.29	22'-6"	.28	27'-0"	.25	35'-0"	.24	41'-0"						
2.5	.44	13'-0"	.40	16'-0"	.37	20'-0"	.35	24'-0"	.31	31'-0"	.30	36'-6"	.29	41'-6"				
3.0	.52	12'-0"	.48	14'-6"	.44	18'-6"	.41	22'-0"	.37	28'-0"	.36	33'-6"	.34	38'-6"				
3.5	.61	11'-0"	.56	13'-6"	.51	17'-0"	.48	20'-6"	.43	26'-0"	.42	31'-6"	.40	35'-6	.38	44'-6"	.36	52'-6"
4.0	.70	10'-6"	.64	12'-6"	.59	16'-0"	.55	19'-0"	.50	24'-6"	.48	29'-0"	.46	33'-6"	.43	41'-6"	.41	49'-0"
4.5	.78	10'-0"	.72	12'-0"	.66	15'-0"	.62	18'-0"	.56	23'-0"	.53	27'-0"	.52	31'-0"	.49	39'-6"	.47	46'-6"
5.0	.87	9'-6"	.80	11'-0"	.73	14'-6"	.69	17'-0"	.62	22'-0"	.60	26'-0"	.57	29'-6"	.54	37'-6"	.52	44'-0"
6.0	1.04	8'-6"	.96	10'-0"	.88	13'-0"	.82	15'-6"	.74	20'-0"	.72	23'-6"	.69	27'-0"	.65	34'-0"	.62	40'-6"
7.0	1.21	8'-0"	1.11	9'-6"	1.03	12'-0"	.96	14'-6"	.87	18'-6"	.84	22'-0"	.80	25'-0"	.76	31'-6"	.73	37'-6"
8.0	1.39	7'-6"	1.28	9'-0"	1.17	11'-6"	1.09	13'-6"	.99	17'-6"	.95	20'-6"	.92	23'-6"	.87	29'-0"	.83	34'-6"
9.0	1.54	7'-0"	1.42	8'-6"	1.30	10'-6"	1.22	12'-6"	1.12	16'-6"	1.07	19'-6"	1.03	22'-0"	.97	28'-0"	.92	32'-6"
10.0			1.59	8'-0"	1.46	10'-0"	1.37	12'-0"	1.24	15'-6"	1.19	18'-6"	1.14	21'-0"	1.08	26'-0"	1.03	31'-0"
11.0							1.50	11'-6"	1.37	15'-0"	1.32	17'-0"	1.27	20'-0"	1.20	25'-0"	1.14	29'-6"
12.0									1.50	14'-0"	1.43	16'-6"	1.38	19'-6"	1.31	24'-0"	1.25	28'-0"
13.0															1.43	23'-0"	1.35	27'-0"
14.0																	1.45	26'-0"
15.0																October 1-1918		

Fig. 220. Chart for quick determination of lighting intensity, spacing of units, proper lamp size and watts per square foot required.

ILLUMINATION COMPUTATION DIAGRAM

The diagram in Fig. 222 is for the rapid calculation or computation of illumination, and is based on an efficiency of utilization of 50%. Curves are given for the various sizes of Mazda "C" lamps, giving the relation existing between the average horizontal illumination on the working plane in foot candles and the area of the room or bay.

Suppose it is desired to illuminate a bay 20′ x 20′ with an average intensity of illumination of 4 foot candles. Referring to the diagram, locate the intersection of the horizontal lines corresponding to an area of 400 square feet with the vertical line corresponding to an illumination intensity of 4 foot candles. The nearest curve passing through this point is the 200 watt curve. Hence, a 200 watt lamp is required.

Again suppose it is desired to know the average intensity of illumination to be obtained with a single 400 watt lamp for an area of 600 square feet. Note the intersection of the 400 watt lamp curve with a horizontal line corresponding to an area of 600 square feet. The vertical line through the point of intersection indicates that the illumination will be about 5 foot candles.

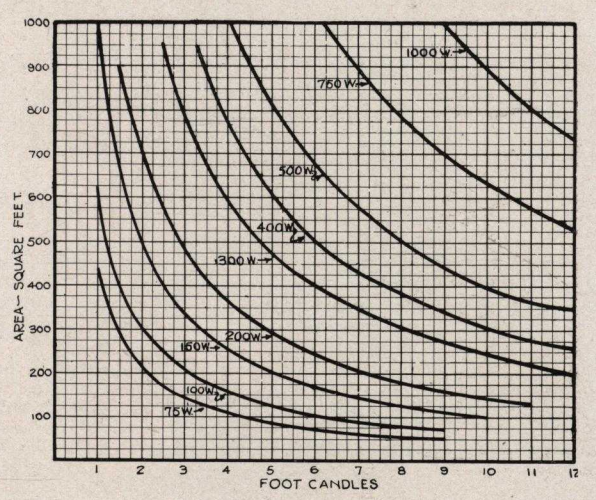


Fig. 222. Diagram for the rapid calculation of lighting intensity from a single lamp for a given area.

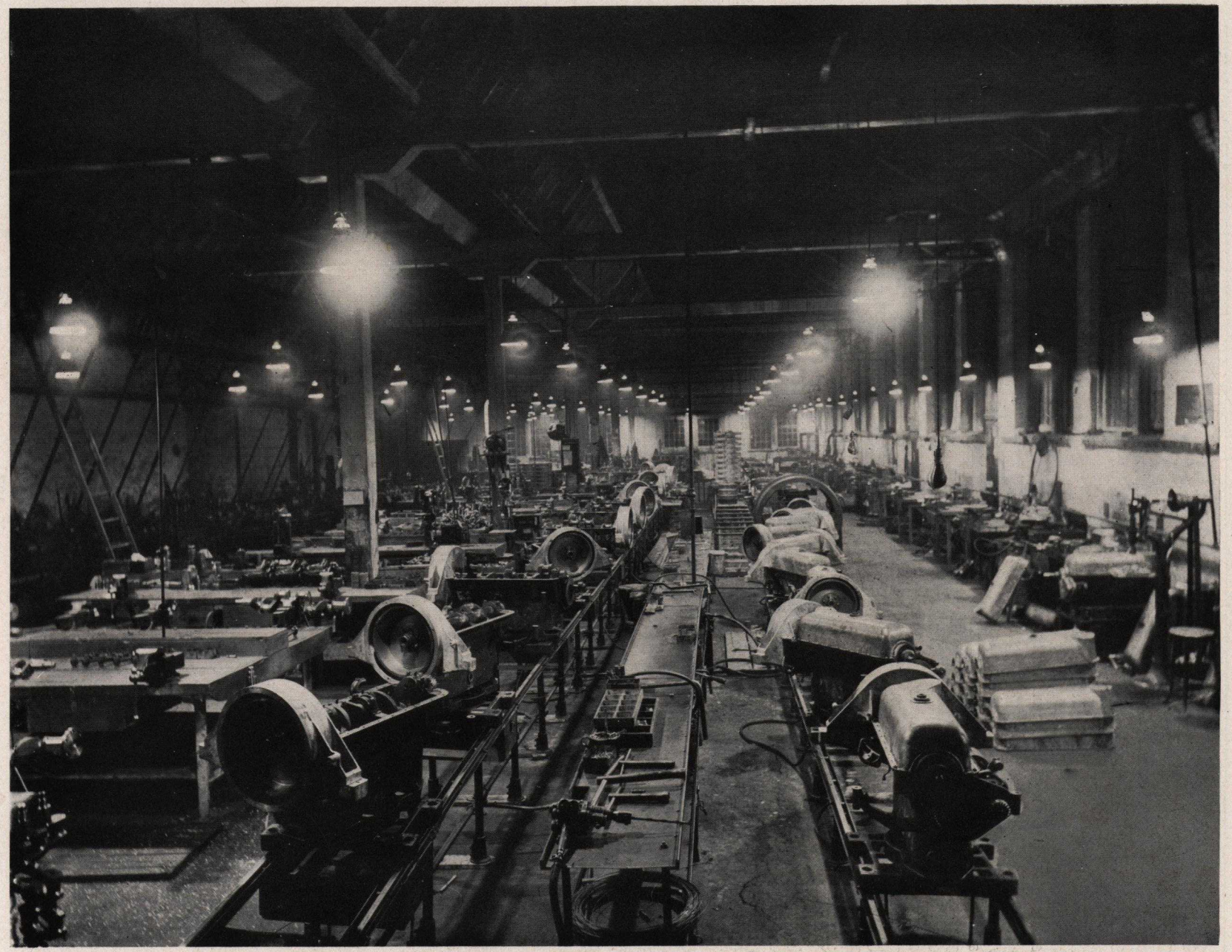


Fig. 223. Motor Assembly Department—Kissel Car Company, Hartford, Wisconsin, Robt. A. Messmer & Bros., Architects, Milwaukee, Wis.

X APPLICATIONS OF DIRECT LIGHTING

PRACTICAL USES IN SHOPS, WORK ROOMS GARAGES, GYMNASIUMS, ETC.

Fig. 224. Work room, The Norton Company, Worcester, Mass.

INDUSTRIAL LIGHTING

THE methods for factory lighting have been practically revolutionized in the last few years. The old drop cord system with individual lights for each bench has been discarded for newer methods which illuminate the entire room evenly. The so-called overhead method of lighting is coming into extensive use. With this method the units are placed high above the heads of the workmen, at or near the ceiling, with the lamps out of ordinary range of vision. This method of lighting permits a clear, unobstructed and glareless view from one end of the shop to the other. It does away with dark corners and harsh shadows, which often contribute to accidents. It gives the room an open, airy and clean cut appearance—a more cheerful place to work.

Good and Bad Lighting

The illustration in Figure 225 shows a condition, as far as lighting is concerned, that exists in many plants today. The illumination is insufficient, not properly distributed, and in many cases important locations are receiving very inadequate light.

Contrast with this the picture in Figure 224. This is a reproduction of a night photograph showing an installation of the distributed outlet system of overhead lighting with X-Ray reflector No. 535. Four 60 watt lamps are used in each 18x18 foot bay. The ceiling height is 11 feet. The practice of using a large number of small lighting units gives a remarkably even and well-distributed illumination. One of the advantages of this system is that if one lamp burns out, there is still ample illumination for the workman to continue with his duty. Note in the photograph that one of the lamps in the second bay is not burning. The effect of this is not noticeable upon the working plane, due to the fact that the lamps all around it are helping out with the illumination.

The use of moderate size units arranged to provide a uniform intensity over the entire surface is desired and preferable to a smaller number of high candle power units placed at greater distances apart.

The distributing types of reflectors are best adapted for factory illumination and cover practically all conditions. In planning the illumination of factories and in selecting the lighting equipment, the following principles should be kept in mind.

1. Protect the eyes by placing the lighting units high above the work and by hiding the lamp.
2. Provide plenty of light for the class of work that is to be done.
3. See that the light is given the proper direction for the purposes of the workmen.
4. Distribute the units to obtain as nearly a uniformity of light as possible.
5. Use the most efficient reflector equipment obtainable.

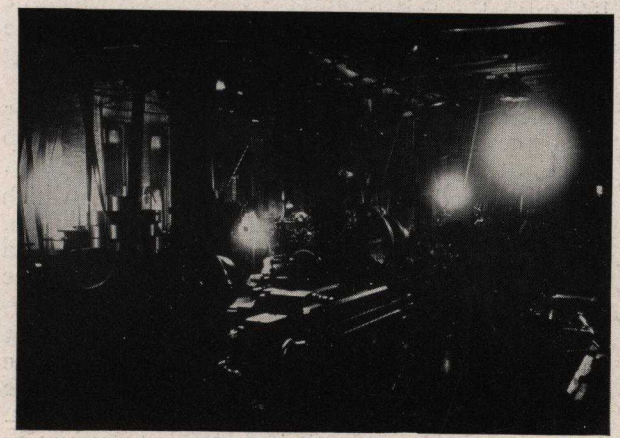


Fig. 225. An example of poor lighting in a manufacturing plant.

TYPICAL EXAMPLE

The illumination requirements and the kind of lighting layout for any class of interior or industry cannot be stated in definite and specific terms, rules cannot be established that can always be followed. Each problem is a new problem, influenced by the work done in the space, and the general character of the surroundings. Many times several kinds of

Fig. 226. Machine shop, Jones Foundry & Machine Company, Chicago, Ill. Davidson & Weiss, Architects.

work are done in the same room. The particular requirements of each should, therefore, be treated separately.

If the building to be lighted is a new one the illumination features can be easily worked into the plans of the architect before the actual work of construction begins. On the other hand, if the building is an old one, alterations and re-arrangements in the existing wiring and lighting scheme are sometimes necessary in order to fulfill the principles of good lighting outlined on the preceding page.

Some of the influencing features will be brought out by considering the lighting of the machine shop space of the Jones Foundry & Machinery Company.

The work done here is rough machining which requires a good intensity of light well distributed. A system of general illumination with overhead units and without drop cords or lights at the machines will be sufficient.

In planning the lighting of a room or department the entire space may be considered as a whole if the character of the work is uniform over the space and if there is architectural uniformity throughout. In most cases, however, it is desirable to reduce or divide the area to the smallest typical area for the purposes of calculation.

By referring to the plan in Figure 227 we find that structually the machine shop is divided into two principle areas, the central space with a high ceiling, and the side areas with a lower ceiling. One of the rectangular areas of each of these spaces will faithfully represent all of the conditions of the whole.

The number and size of units for the lighting of these areas is easily determined by the method of procedure given on page 121.

JONES FOUNDRY AND MACHINERY CO.

Machine Shop

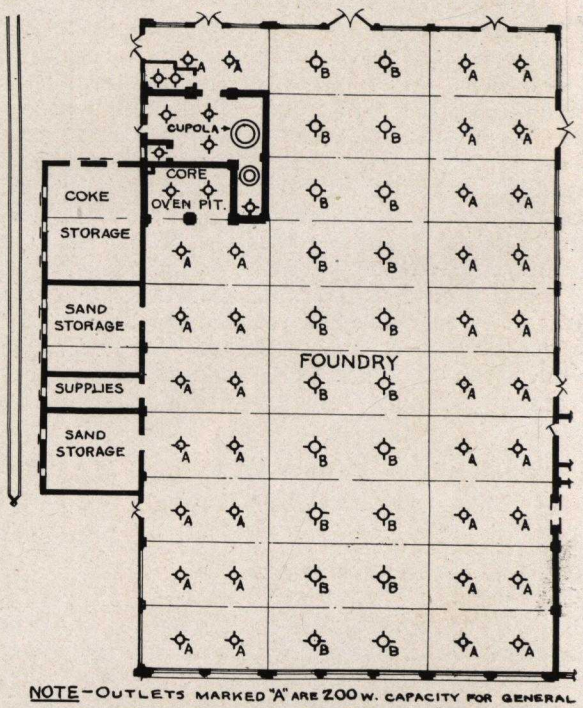
GENERAL NOTES:

Size of center bay—20 x 50 feet.

Floor area per bay—1000 square feet.
Number of units per bay—2.
Type of reflector—X-Ray No. 580.
Lamps per fixture—One 300-watt Mazda "C."
Wattage consumed—.6 watt per square foot.
Reflectors suspended—24 feet, 6 inches from floor.
Reflectors spaced—25 feet apart.

Size of side bay—20 x 38 feet.

Floor area per bay—760 square feet.
Number of units per bay—2.
Type of reflector—X-Ray No. 575.
Lamps per fixture—One 200-watt Mazda "C."
Wattage consumed—.52 watt per square foot.
Reflectors hang—12 feet, 6 inches from floor.
Reflectors spaced—19 feet, 6 inches apart.



NOTE—OUTLETS MARKED "A" ARE 200 W. CAPACITY FOR GENERAL LIGHTING UNDER LOW ROOF. OUTLETS MARKED "B" ARE 300 W CAPACITY FOR GENERAL LIGHTING UNDER MONITOR ROOF.— "A" DENOTES X-RAY Nº 575 REFLECTOR AND "B" THE Nº 580.

Fig. 227. Plan of foundry and machine shop, Jones Foundry & Machine Company, Chicago, Ill.

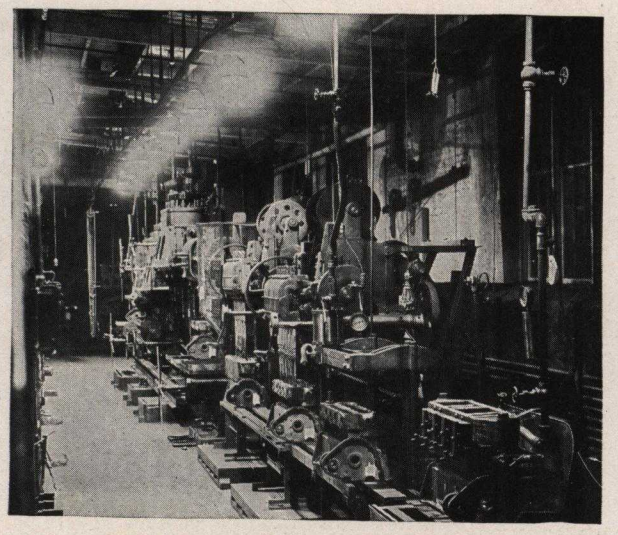


Fig. 228. Cylinder machine department, Kissel Kar Company Hartford, Wis.

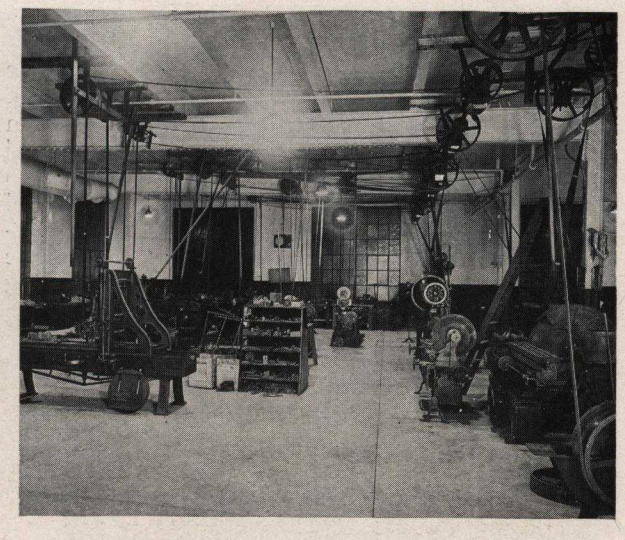


Fig. 229. Paper cutting department, A. P. W. Paper Company, Albany, N. Y.

It is apparent from the plan of the room that for symmetry in spacing and hence a uniform and even lighting two units should be placed in each rectangular area. Hence, the reflectors and lamps in this case were suspended from the structural work midway between the roof trusses.

Structural features are not always as favorable, however, and must in some cases be totally disregarded. Again, the nature of the work done in the space is the most important governing factor in the selection and arrangement of the lighting units.

The requirements for the intensity of the lighting must be carefully determined from the conditions of the particular shop, factory, or workroom. As a general guide in the making of calculations the table No. 3 on page 122 is given. It will be noted that six-foot candles are recommended for general illumination where no local lights are employed. This value of intensity can be obtained with X-Ray reflectors by using less than a watt per square foot. When planning industrial plant lighting, such spaces as drafting rooms, offices, etc., should also be carefully considered.

KISSEL KAR COMPANY, HARTFORD, WIS.

Chassis Assembly Department

GENERAL NOTES:

Type of reflector—X-Ray No. 570.
Lamps per fixture—One 100-watt Mazda "C."
Wattage consumed—1 watt per square foot.
Reflectors hang—9 feet from floor.
Reflectors spaced—10 feet apart.

Cylinder Machine Department

Type of reflector—X-Ray No. 570.
Lamps per fixture—One 100-watt Mazda "C."
Reflectors hang—10 feet, 6 inches from the floor.
Reflectors spaced—7 feet, 6 inches apart.

A. P. W. PAPER COMPANY, ALBANY, N. Y.

Paper Cutting Department

GENERAL NOTES:

Size of typical bay—20 x 20 feet.
Floor area per bay—400 square feet.
Height of ceiling—14 feet.
Number of units per bay—1.
Type of reflector—X-Ray No. 575.
Lamps per fixture—One 200-watt Mazda "C."
Wattage consumed—.5 watt per square foot.
Reflectors hang—13 feet from floor.
Reflectors spaced—20 feet apart.

Fig. 230. Chassis Assembly Department, Kissel Kar Company, Hartford, Wis. Robert A. Messmer & Bros., Architects, Milwaukee, Wis.

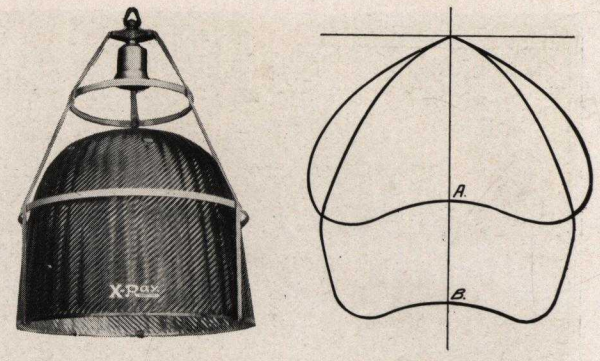
FOUNDRIES

Because of the conditions that prevail in interiors of this kind, a strong, well-directed light is required. The smoky atmosphere, in addition to absorbing a portion of the light delivered by the lamps and reflectors, also causes a deposit of dirt and dust to accumulate on the equipment. Unless a careful schedule of maintenance is established, the installation rapidly loses its effectiveness. Some allowance for these conditions should be made in planning foundry lighting.

Fig, 231. View in the forge room, Stearns Foundry, New Orleans, La.

The X-Ray Reflectors No. 575, No. 580 and "Jumbo," are especially suitable for foundry lighting. They can be installed on the roof trusses overhead and above the cranes. The reflectors can be focused to suit the dimensions of the interior, and give a concentrating light that is especially effective in penetrating smoke.

The Sterns Foundry, illustrated above, was originally illuminated by individual cluster lights hung over each machine, and an extension cord



The "Jumbo" Reflector *Distribution Curves*

Fig. 232. An ideal reflector for high interiors and curves showing how its light can be controlled to suit the interior.

dropped over the drill presses and forges. The present installation eliminates all of this.

Figure 232 shows the "Jumbo" Reflector unit, a type well adapted not only to foundries but to all classes of high interiors, such as erecting shops. The curves in the figure indicate the way in which the light from the "Jumbo" is reflected. The different degrees of "spread" are obtained by moving the lamp up or down. For Curve "B," for instance, the lamp is higher up in the reflector than for Curve "A." For a high, narrow room, the lamp should be adjusted to give the type of distribution shown by "B;" and for a room whose width is greater in proportion to its height, the Curve "A" is better suited.

The illustration below shows the moulding floor of the Jones Foundry. This room has practically the same general plan as that illustrated in Figure 227. The general notes describing that plan will also apply to the moulding floor since the size of the areas are the same and the sizes of the lighting units employed are identical.

Fig. 233. Moulding floor, Jones Foundry & Machine Company, Chicago, Ill. Davidson & Weiss, Architects.

STEARNS FOUNDRY, NEW ORLEANS, LA.

GENERAL NOTES:

Size of room—50 x 310 feet.
Floor area—15,500 square feet.
Number of units—4.
Type of reflector—X-Ray Jumbo unit, No. 54.
Lamps per fixture—One 1,000-watt Mazda "C."
Wattage consumed—.24 watt per square foot.
Reflectors hang—42 feet from floor directly above crane.

Fig. 234. Heavy machine tool department, Hannah Engineering Works, Chicago, Ill.

THE LIGHTING OF HIGH INTERIORS

The typical erecting shop such as illustrated above is difficult to properly illuminate because the lamps must be placed high above the floor, a great distance from where the light is actually used.

The Hannah Engineering Works formerly employed fourteen arc lamps for the illumination of the large construction room shown. These were recessed above the ceiling, forty-four feet from the floor.

The entire lack of control of light from the arc lamps, the high cost of maintenance on account of constant necessity of carbon renewals, and general inefficiency of illumination on the working level made this system entirely unsatisfactory.

An opportunity for a vast improvement in the lighting conditions was seen when X-Ray "Jumbo" reflector units were recommended. The "Jumbos" were installed with 750 watt Mazda "C" lamps and placed in the same recesses formerly occupied by the arc lamps. Each lighting unit takes care of a space 21 by 50 feet.

This equipment controls and directs the light down to the working level so that an even distribution is obtained at an expenditure of only .71 watts per square foot. The maintenance cost of the new equipment is very low, as it is unnecessary to remove either lamp or reflector for cleaning. They can be easily wiped out at regular intervals from the crane.

For interiors of this character, the "Jumbo" and the No. 580 X-Ray reflectors are particularly adapted. They supply a highly efficient, steady light over the area with a minimum of glare and harsh shadows. Both of the above reflectors can be adjusted to direct the maximum amount of light to the floor. See Fig. 232 on opposite page.

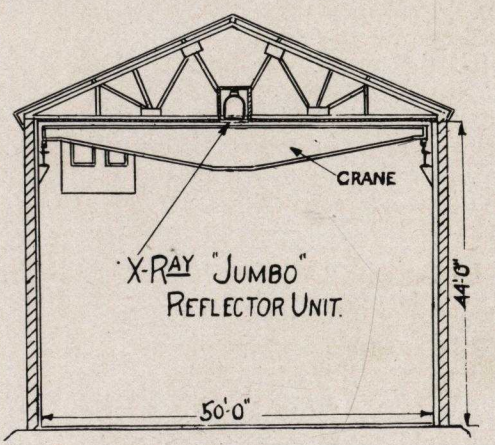


Fig. 235. Cross section of shop, Hannah Engineering Works, Chicago, Ill.

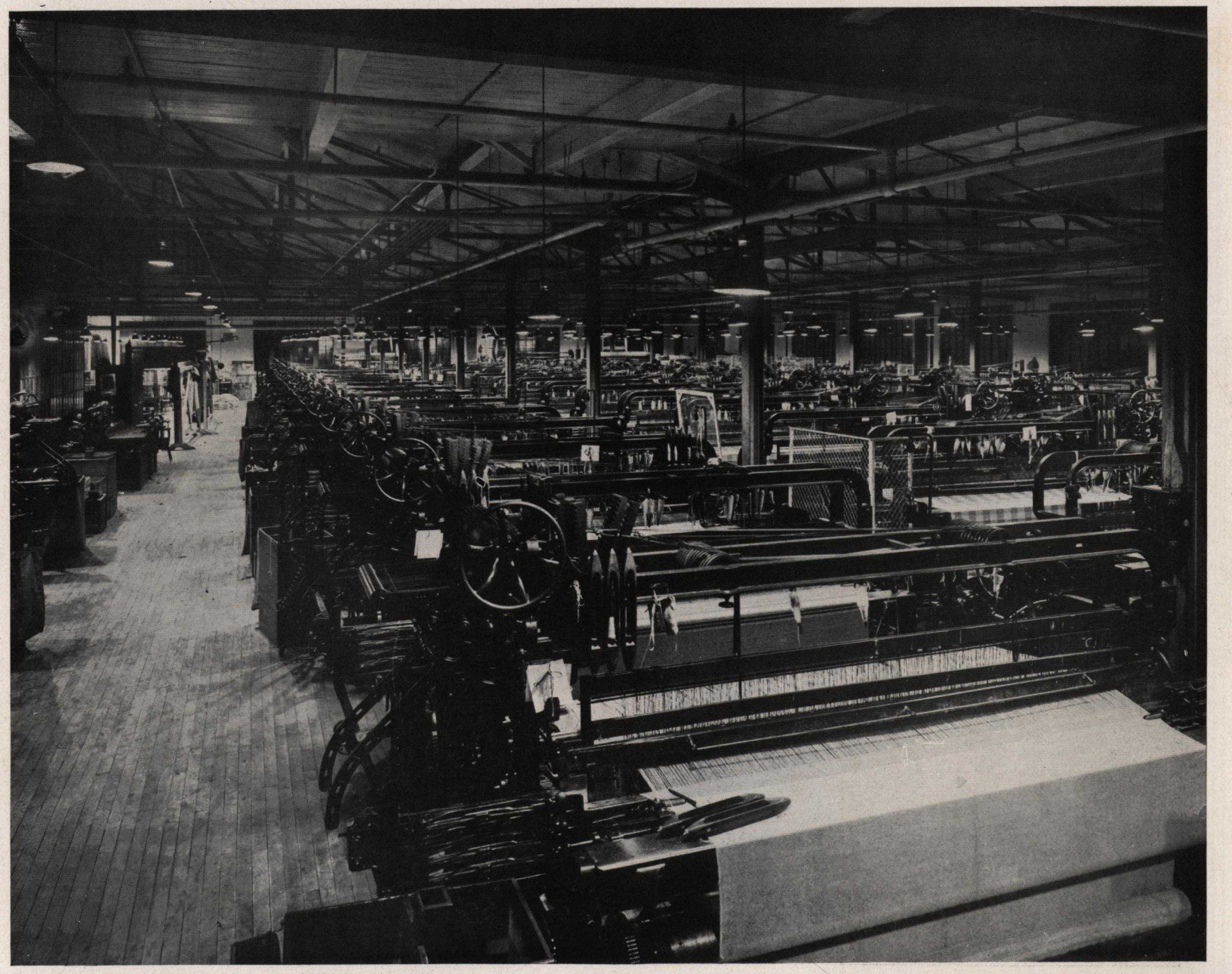


Fig. 236. Weave Room—Seymour Woolen Mills, Seymour, Ind. Snider & Rotz, Engineers, Indianapolis, Ind.

Fig. 237. Work room, Ederer Fish Net Factory, Chicago, Ill. Holabird & Roche, Architects.

Fig. 238. Spooling Department—Stevenson Underwear Company, South Bend, Indiana.

TEXTILE MILLS

The weaveroom illustrated on the opposite page is that of the Seymour Woolen Mills Co., at Seymour, Ind. This company which has been operating its plant since 1864, recently constructed a new weave shed. One of the principal difficulties which they had in the old plant was with the inefficiency of illumination, and it was desired to provide the very best kind of lighting in this weaving department.

The nature of the work here is such that the very best lighting is none too good on account of the necessity for close observation of the work and tying of the broken threads. The looms are wide looms for the weaving of blankets and are spaced on 7-foot centers each way. The type of reflector used is No. 535 X-Ray Reflector with 60 watt Mazda lamp; reflectors mounted 8 feet above the floor and in the aisles 9 feet 6 inches above the floor. The illumination obtained and figured for is a fraction over 5-foot candles on the working plane. The production efficiency of this department has been increased about 20% by reason of the new installation.

The system used in the Seymour weave room may be classed as a local-general system of illumination. (See page 122). A general system is many times just as satisfactory for coarser work, such as spooling, spinning, etc. The lighting installation of the Stevenson Underwear Company is of this nature. Here X-Ray reflectors of the No. 570 type were used, located near the ceiling.

The Seymour installation shows especially the effectiveness of the deep bowl reflector in preventing glare from exposed lamps. One can see about the room with perfect ease and with the light concentrated on the machines every thread is plain.

Indirect lighting is finding a useful application in textile mills because of favorable conditions in modern types of buildings. (See page 56).

SEYMOUR WOOLEN MILLS, SEYMOUR, IND.

Weaving Department

GENERAL NOTES:

Type of reflector—X-Ray No. 535.
Lamps per fixture—One 60-watt Mazda "B."
Wattage consumed—1.22 watts per square foot.
Reflectors hang—8 feet from floor over machines.
9 feet, 6 inches over floor in aisles.
Reflectors spaced—7 feet apart.

Fig. 239. Sewing machine department, Mishawaka Woolen Manufacturing Company, Mishawaka, Ind.

POWER PLANTS

It is necessary in power plants and pumping stations, to provide illumination of good working intensity and to eliminate to a great degree as possible shadows on switchboards, gears, bearings, moving and adjustable parts. It is also of high importance that the plant should never be left in darkness, hence an alternate or an emergency system is sometimes installed.

Fig. 240. Transformer and rotary room, United Electric Light & Power Company, New York City.

An instance of this kind is shown in Figure 240. This room has an alternate lighting system consisting of 5 X-Ray Indirect Lighting fixtures. The indirect lighting system is entirely independent of the direct lighting system and is automatically switched on when anything goes wrong with the direct lighting system.

The transformer room above is 26 feet wide, 89 feet long, with a ceiling 31 feet high. The direct lighting is from twenty X-Ray reflectors of the 570 type, with 100-watt lamps, making the wattage consumption .85 watts per square foot. Each of the indirect lighting fixtures contains a 500-watt lamp. The fixture bowl hangs 42 inches from the ceiling.

BENCH LIGHTING

Where local lighting over benches is required, the scheme shown by the figure below can be very successfully used. The lighting units are located above the heads of the workmen so that no shadows will be cast on the work. If installed in this manner, the light will be properly distributed making it unnecessary for the workman to adjust or tamper with the units.

The recommended spacing for local lighting of this kind is 48 inches between reflectors. This will insure an even lighting. Sufficient intensity of light will be delivered on the work if 40 watt Mazda "B" lamps are used in X-Ray reflectors No. 535.

The drop cord fixture as shown below is made up of X-Ray fittings described on page 120. The receptacle is No. 8053B and the shade holder No. 10100. The reflector unit can be suspended by reinforced asbestos cord from an outlet box or from a standard conduit fitting.

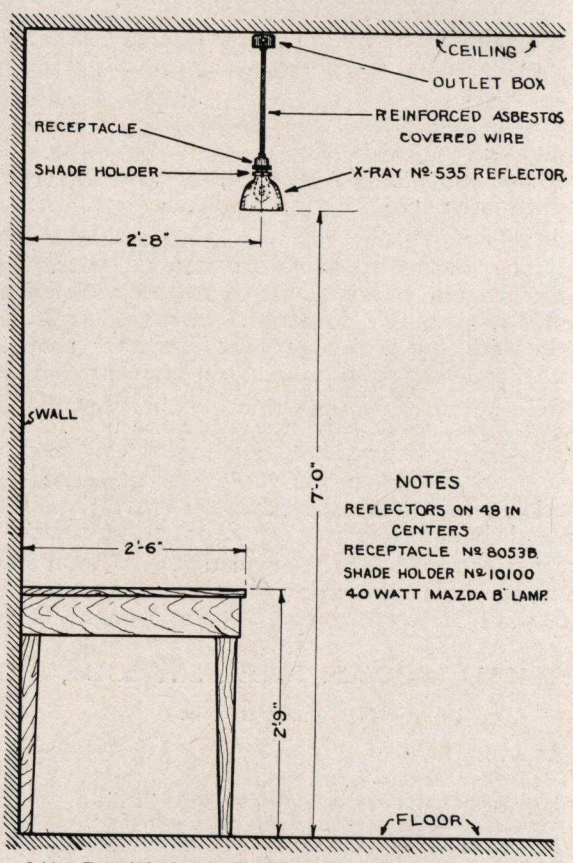


Fig. 241. Bench lighting. Diagram indicates the proper location of reflectors for local lighting over benches and work tables.

Fig. 242. Composing room, before installing X-Ray lighting, Stromberg-Allen Company, Chicago, Ill.

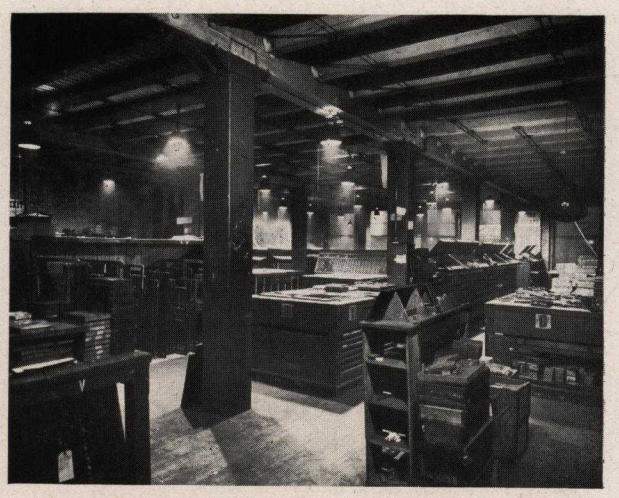


Fig. 243. Composing room, after installing X-Ray lighting. Stromberg-Allen Company, Chicago, Ill.

PRINTING PLANTS

In the room pictured above four times as much light is received as with the old equipment, and the cost of current is only two-thirds as great—poorly diffused lighting and glare have been eliminated.

The average printing plant is divided into a number of practically independent areas where special kinds of work are being done and each of these areas require individual attention when the lighting is being planned.

The wattage required, the type of reflector, and its hanging height must be determined for each individual outlet, keeping in mind, the nature of the work that is to be done under the artificial light.

Typesetting and hand composition are among the most difficult operations in the printing plant and require a strong, well shaded light. The local general system like that shown in Figure 243 is best for these departments.

A more general illumination can be provided in the pressroom, although the feed and delivery ends of the press must have a strong light.

Imposing stones require an intensity as great as that provided for the typesetting. A 100 watt lamp and an X-Ray No. 570 reflector over the center of the stone is found to be very satisfactory (see diagram below).

In addition to general illumination of linotype machines, it is necessary that a local light be used at the keyboard.

For small machines such as saws, paper cutters, casting machines, etc., good general lighting is all that is required.

A typical typesetting plant is shown diagram-

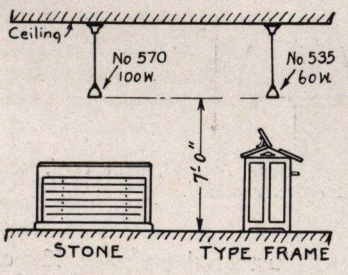
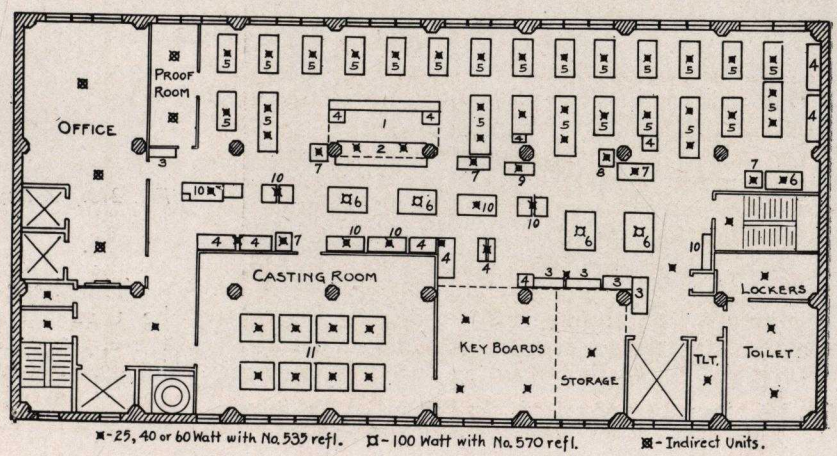


Fig. 244. Diagram showing proper location of lighting units in printing plants.

Fig. 245. Floor plan at right shows typical type-setting plant. Correct placing and capacity of various units are indicated.



matically in Figure 245. Notations are made as to the kind of lighting, kind of reflector and size of lamp that are to be used in each department.

X-Ray Indirect lighting is recommended for the office and proofreading room and X-Ray direct light for such places as storage, toilet, open areas, locker rooms, keyboard department, etc. General illumination is satisfactory for all of these spaces.

Localized illumination is recommended for the Composing Department and Casting Department.

Wattage Required

For office and proofing reading—1½ watts per square foot with X-Ray indirect lighting.
Storage, etc., .2 watt per square foot for X-Ray direct Lighting.

Composing Department.

No. 1, Foreman's desk, two 75-watt lamps.
No. 2, Copy rack, two 60-watt lamps.
No. 3, Galley slides, one 40-watt lamp.
No. 4, Galley rack, one 40-watt lamp.
No. 5, Type frames, one 60-watt lamp.
No. 6, Large stone, one 100-watt lamp.
No. 7, Proof press, 140-watt lamp.
No. 8, Saw, 125-watt lamp.
No. 9, Paper rack, 160-watt lamp.
No. 10, Small stone, one 75-watt lamp.
No. 11, Casting machine, one 75-watt lamp.

Number of Lamps

The spacing of the units is in accordance with the location of cases, stones, etc., as indicated in the diagram, on the previous page.

Hanging Heights

In the Storage Department, etc., units should be at the ceiling. In the Composing Department the reflectors are 7 feet from the floor over stones and cases and 8 feet from floor over the foreman's desk. In the casting department reflectors are 5 feet 6 inches above the floor.

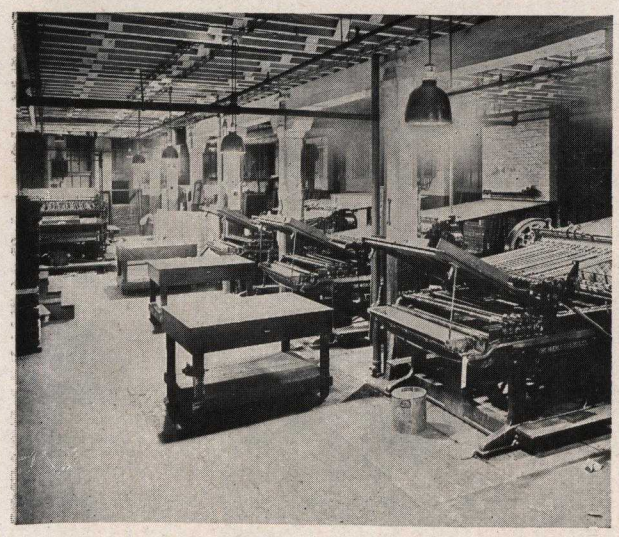


Fig. 246. Press room, Maryland Color Printing Co., Baltimore, Md. No. 575 X-Ray reflectors, 200 watt lamps.

Individual Control of Units

In printing plants and those departments of factories where the machines are not kept in constant use, individual control of lighting is desirable. The saving in current consumption pays for the equipment in a short time.

The fitting illustrated here is recommended for the purpose of controlling X-Ray direct lighting reflector units.

Another method for controlling units individually is detailed on page 155.

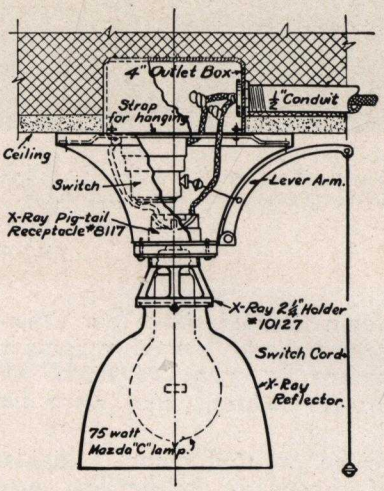


Fig. 247. X-Ray ceiling fitting No. 20, as attached to any ordinary outlet box.

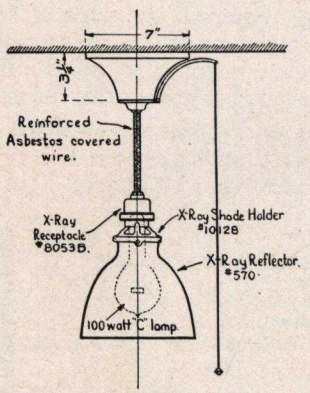


Fig. 248. X-Ray canopy fitting No. 38, with cord, socket and reflector added.

The shade holders illustrated on page 120 can be used interchangeably on the above fittings, thereby adapting the unit to various reflectors and lamps. For Mazda "C" lamps and a bulb of the 75-watt size the stem type of suspension given on page 120 is recommended.

ARMORIES

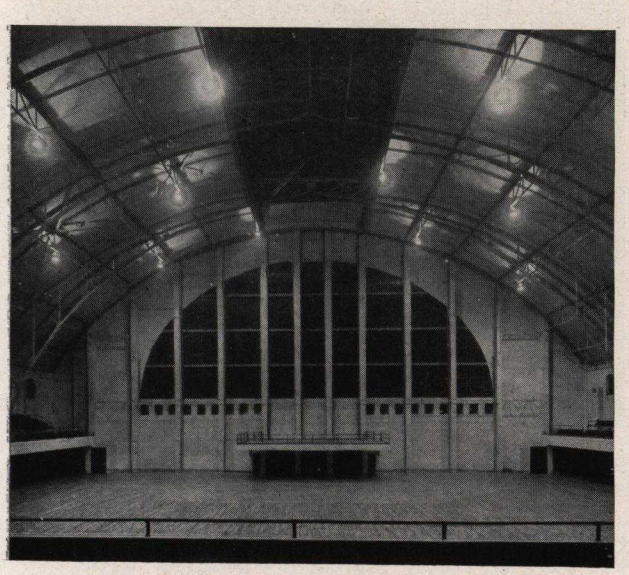


Fig. 249. Drill hall, Second Regiment Armory, Chicago, Ill. Jas. B. Dibelka, Architect.

For big interiors, like that illustrated above, rooms of enormous proportions with high arched ceilings, the equipment installed must throw the light from a comparatively great height, and provide an even distribution on the floor. The units must be accessible, easily cleaned, and of such design as to conceal the light source.

On page 152 are shown the details of the lighting arrangements for the large Armory at the University of Illinois. This interior is 200 feet wide and 400 feet long. The height of the roof at the center of the arches is 100 feet from the floor. Special provisions were made in this installation for the lowering of the lighting units to the floor for cleaning and renewal of lamps. All lowering cables, wiring circuits, etc., are cleverly concealed in the steel structure of the building. Several lighting methods were considered, such as, lamps along the lower sides of the trusses and steel work, arc lamps suspended from the ceiling, etc., before the X-Ray "Jumbo" were finally installed.

The State of Illinois recently appropriated $500,000.00 for a new Armory to house the Second Regiment of the Illinois National Guard. The building contains in addition to the main drill hall, see Figure 249, a large gymnasium, an assembly room, various company rooms, private offices for field officers and army instructors, locker rooms, rifle ranges, etc.

Twenty X-Ray "Jumbos," with 1000-watt lamps, light the drill hall; in the gymnasium, twelve X-Ray No. 575 Reflectors are used, with 200-watt lamps; in the assembly room, officers' and company rooms, X-Ray Indirect Lighting was installed.

SECOND REGIMENT ARMORY, CHICAGO, ILL.

Drill Hall

GENERAL NOTES:

Size of room—200 x 200 feet.
Floor area—40,000 square feet.
Height of ceiling—100 feet at center.
Number of units—20.
Type of reflector—X-Ray Jumbo unit, No. 54.
Lamps per fixture—One 1,000-watt Mazada "C."
Wattage consumed—.5 watt per square foot.
Reflectors hang on roof trusses.
The entire Armory, including the gymnasium, assembly hall, Company rooms, etc., is illuminated with X-Ray direct and indirect lighting.

FIFTH REGIMENT ARMORY, BALTIMORE, MD.

Band Platform

GENERAL NOTES:

Size of platform—45 x 90 feet.
Area—4,050 square feet.
Number of reflector units—48.
Type of reflector—X-Ray No. 575.
Lamps per fixture—One 200-watt Mazda "C."
Wattage consumed—2.3 watts per square foot.
Reflectors arranged in 6 rows of 8 each.
Reflectors suspended 10 feet above rear of platform.

Fig. 250. Band platform, Fifth Regiment Armory. Baltimore, Md.,

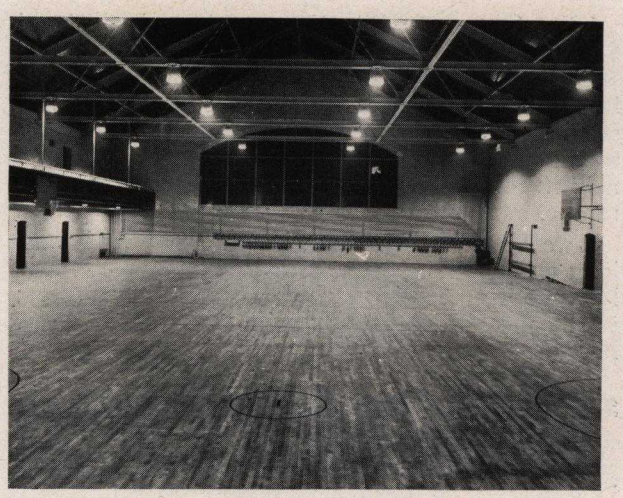


Fig. 251. Gymnasium, DePauw University, Greencastle, Ind. Ammerman & McColl, Engrs., Detroit, Mich.

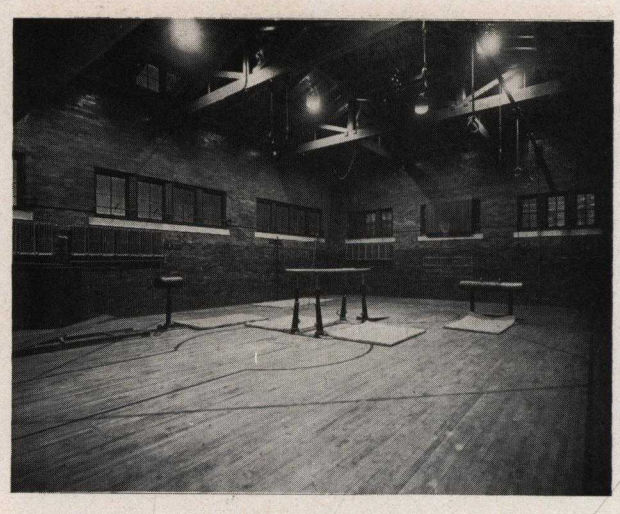


Fig. 252. Typical gymnasium interior for Playground Parks, West Park Board, Chicago, Illinois.

GYMNASIUMS

Gymnasium activities are largely carried on by artificial illumination, especially in the Y. M. C. A. and the play ground parks of our large cities. The benefits of the exercise will therefore be directly proportional to the satisfactory character of the lighting system employed. The general arrangements of the lighting units are given in the figures below.

The reflector units installed in gymnasiums should be protected by wire guards against damage by balls and swinging apparatus. Guards do not affect the lighting results. Their fastenings should be independent of the reflector units.

DE PAUW UNIVERSITY, GREENCASTLE, IND.

Gymnasium

GENERAL NOTES:

Size of room—80 x 160 feet.
Floor area—12,800 square feet.
Height of ceiling—43 feet at center.
23 feet, 4 inches from floor to truss.
12 feet under balcony.
Number of units—32. Under balcony, 9.
Type of reflector—X-Ray No. 575.
X-Ray No. 570 under balcony.
Lamps per fixture—200-watt. Under balcony 100-watt Mazda "C"
Wattage consumed—.57 watt per square foot.
Reflectors suspended from bottom of truss.

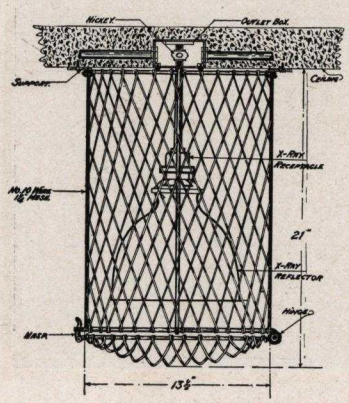


Fig. 253. Gymnasium lighting fixture.

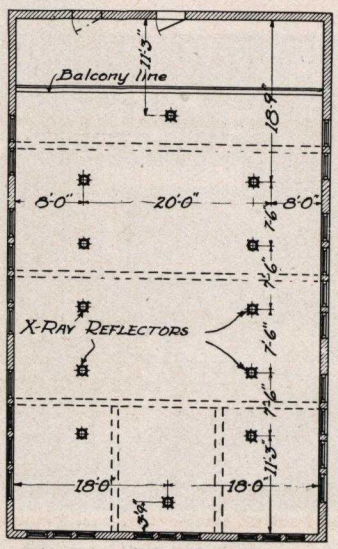


Fig. 254. Plan of West Park Gymnasium.

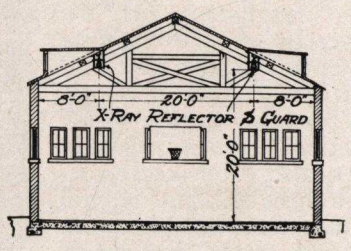


Fig. 255. Section of West Park Gymnasium.

Fig. 256. Typical Commercial Garage lighted with deep bowl X-Ray Reflectors.

Fig. 257. Service Station—Hudson Motor Car Company, New York City, New York.

GARAGES

The small private garage for one car, as well as the large commercial garage needs a carefully planned lighting system. Most of the inconvenience, delay and danger in making repairs can be eliminated by providing plenty of well-diffused light in the garage. Figure 256 shows a standard, commercial garage. Figure 257 is the Hudson Service Station in New York City. Below is a plan of the first floor of the commercial garage shown in Figure 256, with the location clearly indicated for the various lighting units employed.

It will be noted that a different arrangement of units has been planned for the storage space than for the central area of the room. X-Ray reflectors No. 535 with 60 watt lamps are used for the storage space while a larger reflector, X-Ray No. 570 with 100 watt lamps are used to light the central area.

At the rear of the room, the washing stands or racks are located. Special lighting is provided by means of X-Ray Jupiter reflectors No. 610, one at each corner of the washing area. This type of reflector is employed to throw a strong light on all sides and on the top of the car that is being washed. All of the reflector units for the installation are installed on stems with X-Ray receptacles and shade holders as illustrated on page 120.

In the shop, two units at the ceiling supply the general illumination, while the bench near the windows is provided with lamps suspended as shown in the diagram on page 136.

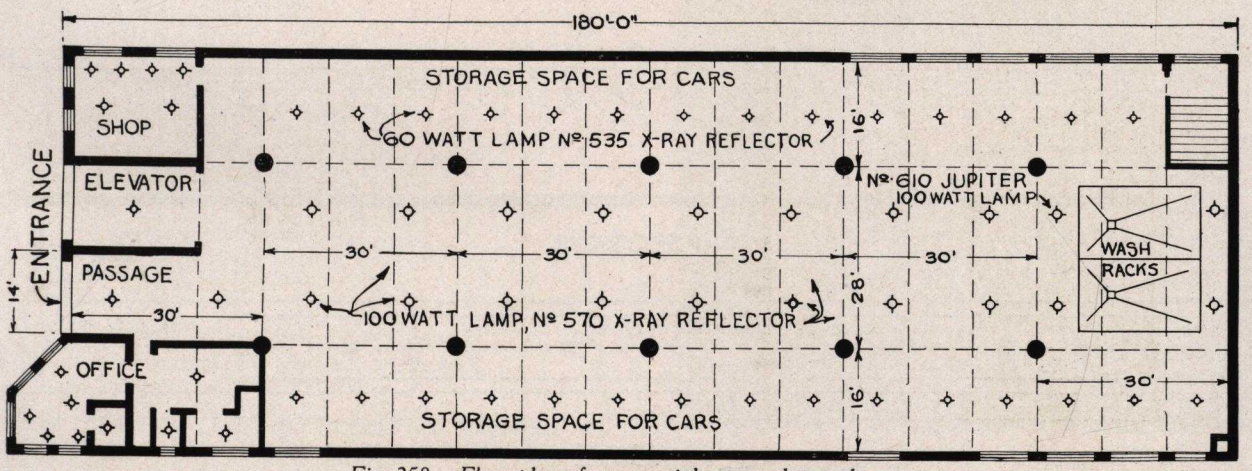


Fig. 258. Floor plan of commercial garage shown above.

BILLIARDS AND POOL TABLES

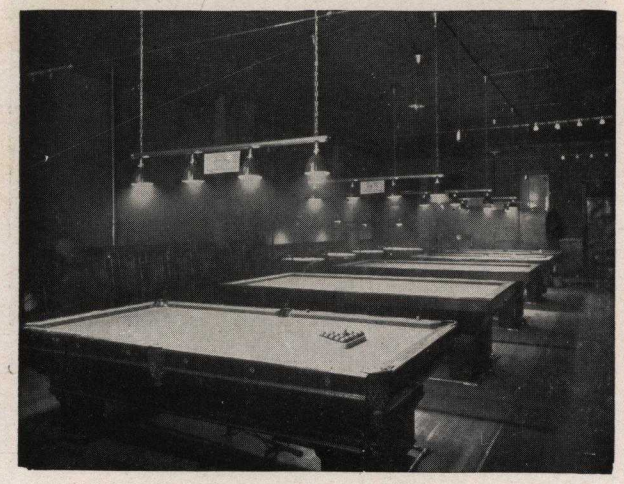
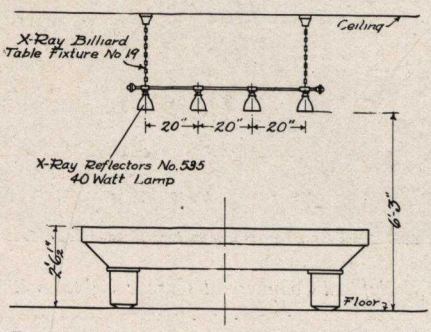


Fig. 259. Billiard tables, Quinn & Company, Chicago, Ill.

The arrangement for billiard and pool table lighting as shown in the diagram indicates a method for obtaining practically ideal lighting for this type of service. Evenness of illumination on the table is perfect and the expenditure for wattage is low, as only four 40 watt lamps are required.

Bowling Alleys

For the lighting of bowling alleys, the important requirements are to supply even illumination over the surface of the alley and a strong light at the pins. It is very essential also to conceal the lamp from view. The scheme below will eliminate alternate dark and light spots that tend to give the alley a wavy appearance very annoying to the players. The location of lighting units for proper bowling alley illumination are given. The dimensions given are for a standard bowling alley. Eight X-Ray reflectors No. 535 with 40 watt lamps should be placed 6 feet 6 inches above the alley as indicated. For the illumination of the pins, an X-Ray



Detail of the lighting arrangement for the Quinn & Co. billiard tables.

Scoop reflector No. 778 with a 75 watt lamp located 5 feet 3 inches from the edge of the tip and 3 feet 6 inches above the alley gives excellent results.

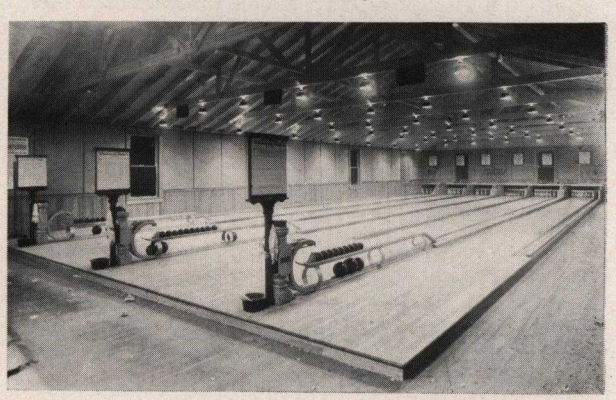


Fig. 260. Hamilton Bowling Alleys, Baltimore, Maryland.

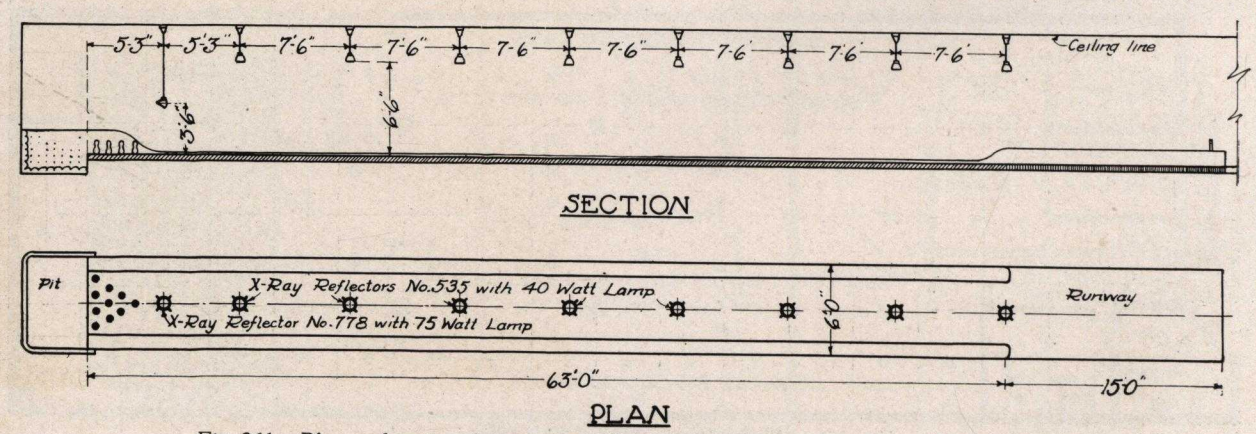


Fig. 261. Plan and section showing proper lighting arrangement for standard bowling alley.

SWIMMING POOL

Fig. 262. Swimming pool, Northwestern University, Evanston, Ill. George W. Maher, Architect, Chicago, Ill.

In the illumination of a swimming pool the room must appear bright and at the same time the source of light must be so screened as not to be annoying to the observer in the balcony and at other points.

These conditions were successfully met at the Northwestern University by using 12 special fixtures located at the ceiling.

Opaque X-Ray reflectors in the box fixtures direct all of their light to the floor plane, thus shielding the lamp from those in the balcony watching the swimming contests, water polo, or other water games. The lighting of the ceiling and upper walls has in this case been provided by using a few additional lamps of low candle power around the upper part of the opaque reflector in the art glass boxes.

NORTHWESTERN UNIVERSITY, EVANSTON, ILL.

Swimming Pool

GENERAL NOTES:

Size of room—44 x 71 feet.
Floor area—3,124 square feet.
Height of ceiling—16 feet.
Number of units—12.
Type of reflector—X-Ray No. 575.
Lamps per fixture—One 150-watt Mazda "C."
Wattage consumed—.57 watt per square foot.
Reflectors hang—13 feet from floor.

On page 147 is an interesting example of swimming pool lighting by means of a ceiling skylight.

SQUASH RACKET COURT

The indoor game squash rackets is played with a heavy black rubber ball about 1½ inches in diameter, and with rackets somewhat similar to tennis rackets except that they weigh considerably more. The game is an exceedingly fast and strenuous one, and the utmost accuracy is required in placing the ball. It will be appreciated that for a game of this sort the standard of illumination must be very high.

A very successful installation with X-Ray reflectors is to be found in the Philadelphia Athletic Club. Twelve reflectors, in pairs, are located behind the ceiling beams which are 6 feet deep. It is impossible for the player to see the lamps unless he looks vertically upwards.

The illustration of the room is somewhat deceptive, and does not show it up in its true proportions. The dimensions are 30 feet wide, 54 feet long, and 36 feet for the ceiling height.

PHILADELPHIA ATHLETIC CLUB, PHILADELPHIA, PA.

Squash Court

GENERAL NOTES:

Size of room—30 x 54 feet.
Floor area—1,635 square feet.
Height of ceiling—36 feet.
Number of units—12.
Type of reflector—X-Ray No. 575.
Lamps per fixture—One 200-watt Mazda "C."
Wattage consumed—1.47 watts per square foot.
Reflectors hang—30 feet from floor.

Fig. 263. Squash tennis court, Philadelphia Athletic Club, Philadelphia, Pa.

Fig. 264. Letter cases United States Postal Substation.

LETTER CASES

The buildings for outlying postal stations in cities and in small towns are usually owned by private individuals and rented to the United States Government. The interior arrangements of these stations are, however, planned by an expert experienced in the handling and dispatching of mail. He determines the location of tables, racks, and cases for the greatest efficiency. The lighting details also come under his supervision. In a number of recent installations it has been found that the revision of the lighting system, both for the general illumination of the station and the localized lighting of the cases has resulted in a great saving in wattage and wiring cost over the older methods employing gas units and metal shades. In one station the monthly bills for lighting were reduced by 50%.

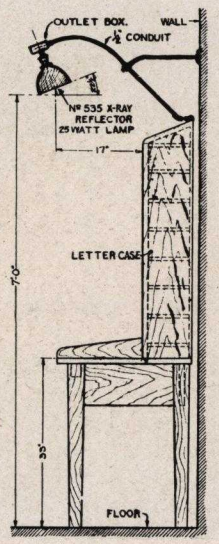


Fig. 265. End elevation of typical letter case showing proper method of installing X-Ray reflectors.

Fig. 266. Market department, West Lake public market, Seattle, Wash.

The figure below shows the method adopted for letter case lighting. Each unit provides illumination for two dispatchers.

PUBLIC MARKET

The basement and ground floors of the West Lake Public Market are occupied by stalls and selling booths arranged in an irregular fashion. When the old system of unshaded lamps was replaced with the X-Ray equipment, the first move was to eliminate all drop cords and to place the reflectors at the ceiling. The ceiling varied in height from 9 to 20 feet. Where the ceilings are low reflectors No. 535 with 50 watt lamps are used. On the higher ceilings the reflectors No. 570 with 100 watt lamps are employed. In the Meat Department, X-Ray scoop reflectors No. 778 are used for the lighting of the counters and cages.

Fig. 267. Grocery department, West Lake public market, Seattle

SKYLIGHT LIGHTING

Fig. 268. Atrium, Hartford City Hall, Hartford, Conn. Davis & Brooks, Architects.

Skylight illumination is without doubt a most ideal method of lighting because its perfect diffusion and softness. To be satisfactory this method must employ reflectors of highest efficiency. These reflectors must be correctly designed so as to spread the light evenly over the glass. Skylight illumination is especially adapted for art galleries, school rooms, churches, assembly halls, etc.

Figure 268 illustrates the Atrium of the Hartford City Hall, Hartford, Conn. The photograph from which this reproduction was made was taken at night by the aid of the lighting units above the skylight.

The only means for supplying daylight for the Atrium is through the large ceiling skylight. Obviously then to get the artificial daylight effect at night the artificial illumination must also come through the skylight.

Uniform ceiling brightness and sufficient intensity of light on the first floor were among the problems to be solved in this installation. More than 300 X-Ray direct lighting reflectors are suspended above this glass arranged in 15 rows. The units are wired in two circuits in such a manner that when only one-half the lights are burning, uniform illumination is still obtained over the skylight.

The Atrium is 42 feet wide, 116 feet long and 56 feet from the first floor to the center of the ceiling.

In all of the offices, lavatories and corridors of the building, the X-Ray indirect lighting system of illumination is used.

HARTFORD MUNICIPAL BUILDING HARTFORD, CONN.

Atrium or Public Lobby

GENERAL NOTES:
Size of room—42 x 116 feet.
Floor area—4,872 square feet.
Height of ceiling at center—56 feet from floor.
Lighting units located above skylight.
Number of units—300.
Type of reflector—X-Ray No. 570.
Lamps per fixture—One 100-watt Mazda "C."
Reflectors hang—8 feet above skylight.
Reflectors arranged in 15 rows.
Reflectors spaced—3 feet by 6 feet apart.

Cleveland Museum of Art

The system proposed and installed by the Committee on lighting equipment for the Museum of Art, represents the most modern practice in the illumination of buildings of this character.

Many of the exhibition rooms contain no windows, both the day lighting and artificial lighting are provided through a ceiling skylight.

Because of the effect of the quality of artificial illumination upon the paintings, and other colored objects on exhibition, the daylight lamp or Mazda C-2 lamp was employed practically throughout the building.

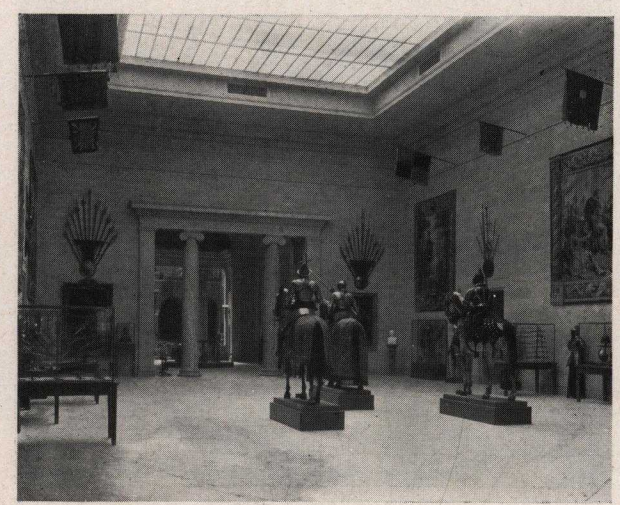


Fig. 269. Court of Tapestries and Armor, Cleveland Museum of Art, Cleveland, Ohio. Hubbell & Benes, Architects.

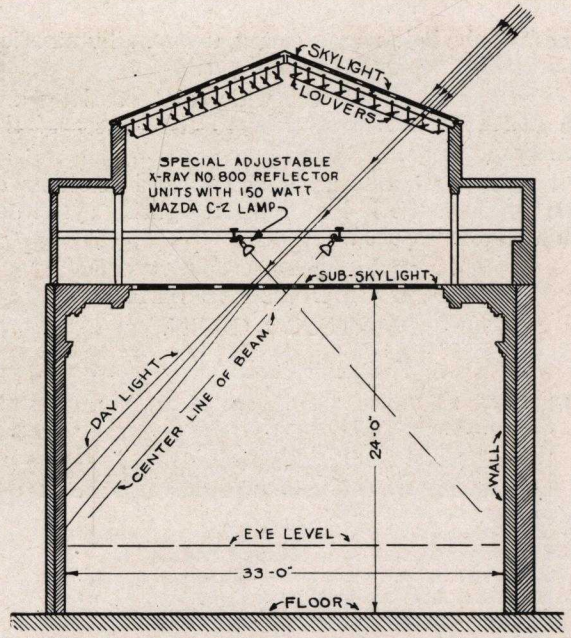


Fig. 270. Cross section of typical painting gallery, Cleveland Museum of Art, Cleveland, Ohio.

CLEVELAND ART MUSEUM, CLEVELAND, O.
Painting Gallery

GENERAL NOTES:
Size of room—33 x 55 feet.
Floor area—1,815 square feet.
Height of ceiling—24 feet.
Lighting units located above skylight.
Type of reflector—X-Ray No. 800.
Lamps per fixture—One 150-watt Mazda "C."
Reflectors located as shown in diagram above.
One light installed for each three or four feet of wall length.

Fig. 271. View above sub-skylight of typical painting gallery, showing artificial lighting units, Cleveland Museum of Art, Cleveland, Ohio.

Fig. 272. Operating room, Cook County Hospital, Chicago, Ill. R. E. Schmidt, Garden & Martin, Architects.

Hospital Operating Rooms with Skylight

An excellent system of diffused illumination for hospital operating rooms is used in the Cook County Hospital of Chicago, Illinois.

A view of one of the rooms is shown above. The lighting units are concealed behind glass panels in the ceiling in the manner indicated in Figure 273. The glass door is hinged to allow for the cleaning and renewing of reflectors and lamps.

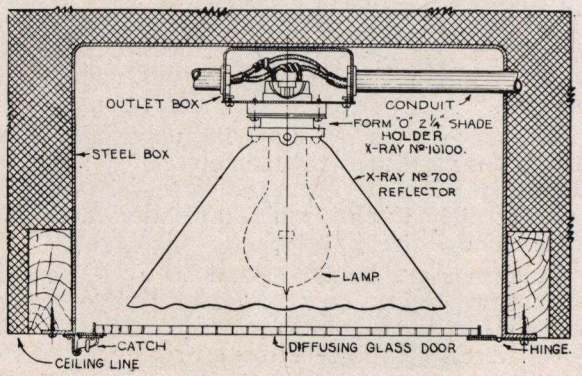


Fig. 273. Detail of lighting arrangement used for operating room shown above.

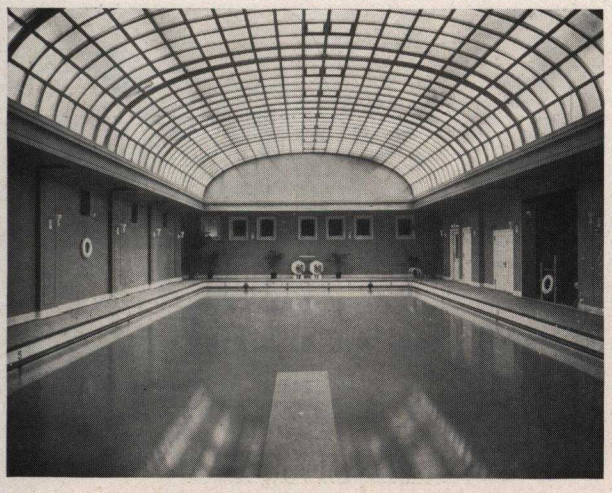


Fig. 274. Swimming pool, Union League Club, Chicago, Ill.

Swimming Pool

The daylight effect in the swimming pool above is due to a perfect illumination of the ceiling by means of the large number of small units, spaced closely together. The effect is an unusually uniform brightness on the sub-skylight. Swimming pool lighting with direct lighting units is describd on page 143.

UNION LEAGUE CLUB, CHICAGO, ILL.

Swimming Pool

GENERAL NOTES:

Size of room—40 x 75 feet.
Floor area—3,000 square feet.
Height of ceiling at center—20 feet.
Lighting units located above skylight.
Number of units—135.
Type of reflector—X-Ray No. 570.
Lamps per fixture—One 75-watt Mazda "C."
Wattage consumed—3.4 watts per square foot.
Reflectors hang—4 feet above skylight glass.
Reflectors spaced on 4 foot centers.
Reflectors arranged in 9 rows of 15 reflectors each.

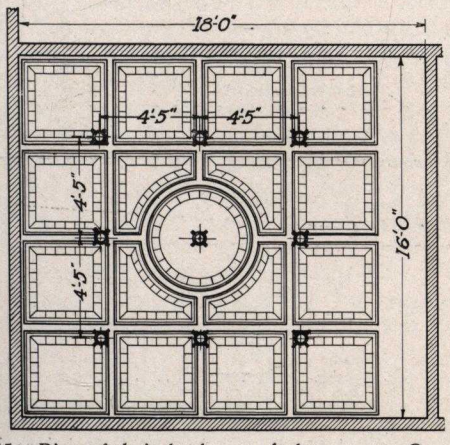


Fig. 275. Plan of skylight showing lighting units, Central Trust Company, Chicago, Ill.

Fig. 276. Private office Central Trust Co. of Chicago, Ill. Mundie & Jensen, Architects.

Glass

The consideration of the glass employed for skylight is of the highest importance because of the loss that results from passing the light through the glass. In the making of calculations for installations where the reflector units are placed above the skylight it is necessary to make allowances for the absorption of the glass. On page 237 a table is given showing the amount of light absorbed by various kinds of glass. Those which are low in absorption are best for skylight purposes. The absorption, however is not the only feature to be taken into consideration. The kind of glass selected should also be of such character as to shield or prevent a view of the equipment above the glass. Clear glass is not desirable. Glass with a roughened surface, cut up in such a way as to diffuse the light is recommended.

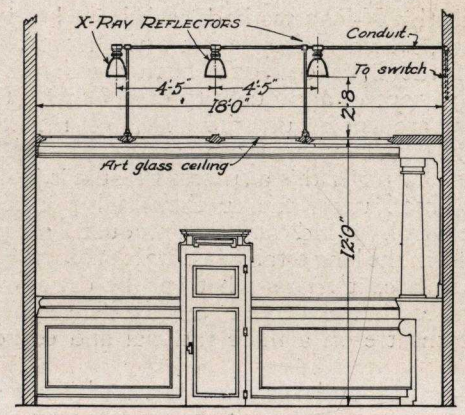


Fig. 277. Section of private office Central Trust Company of Chicago, Ill.

STAGE LIGHTING

When David Belasco remodeled his theater at the close of the 1915 season, the stage lighting equipment was entirely redesigned and a method was devised which is a radical departure from the ordinary practice for stage lighting.

The results produced by this new scheme are so different and so far in advance of the ordinary effects and at such a great saving for electric current that other producers have followed Mr. Belasco's lead by giving more careful thought to the artistic and economical lighting of the stage.

The "Boomerang" was the first play to be presented with the new lighting system. Footlights and footlight construction were entirely eliminated. All of the light was thrown upon the stage from above by strips such as described on page 153. This plate shows the location of the lighting system back of the draperies and indicates the simplicity of the entire scheme.

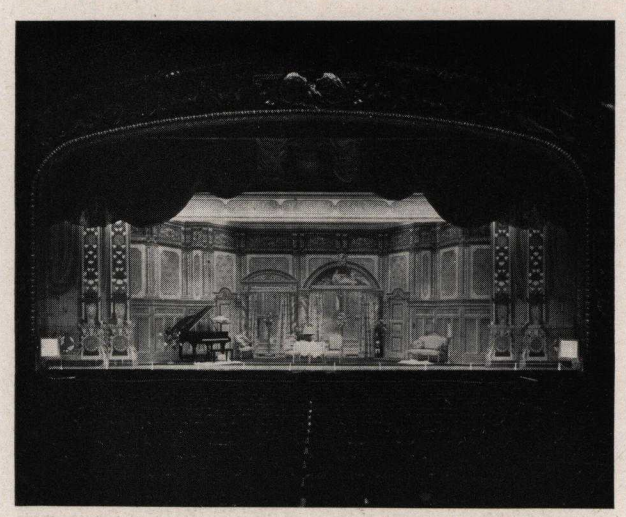


Fig. 278. The Stage—Audubon Theatre, New York City, N. Y.

With this X-Ray method, each lamp has its own reflector, which makes possible the most effective use of the light delivered from the lamp. The losses in control and quantity of light with the old borders are enormous. The Belasco method has brought efficiency into stage lighting.

This new method is a success because it is scientifically based upon the fundamental principles of light control. It indicates that producers are getting away from the long established style of stage lighting. Furthermore, it shows what can be done and will be achieved in the future to put the lighting features of the theatre on a more rational and economical basis.

Figures 281 and 282 show sectional views of the stage lighting equipment made up with X-Ray reflectors.

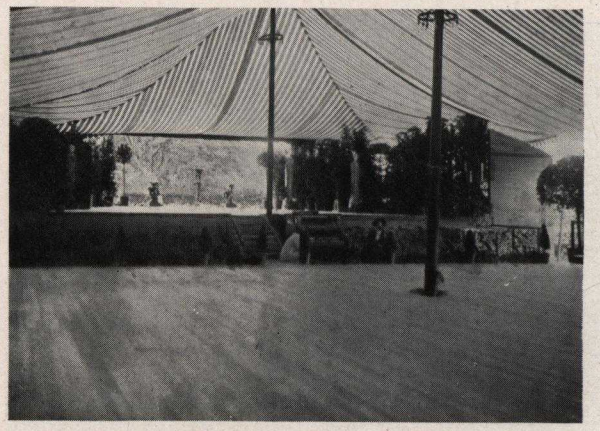


Fig. 279. Outdoor stage, estate of Mr. James L. Breese, Southampton, Long Island.

LIGHTING FOR OUTDOOR PLAYS

The past few years have seen a rapid development in interest for the outdoor theatre in the revival of certain types of simple plays, masques, etc. These outdoor plays are closely allied in their dramatic and mechanical aspects to the indoor production.

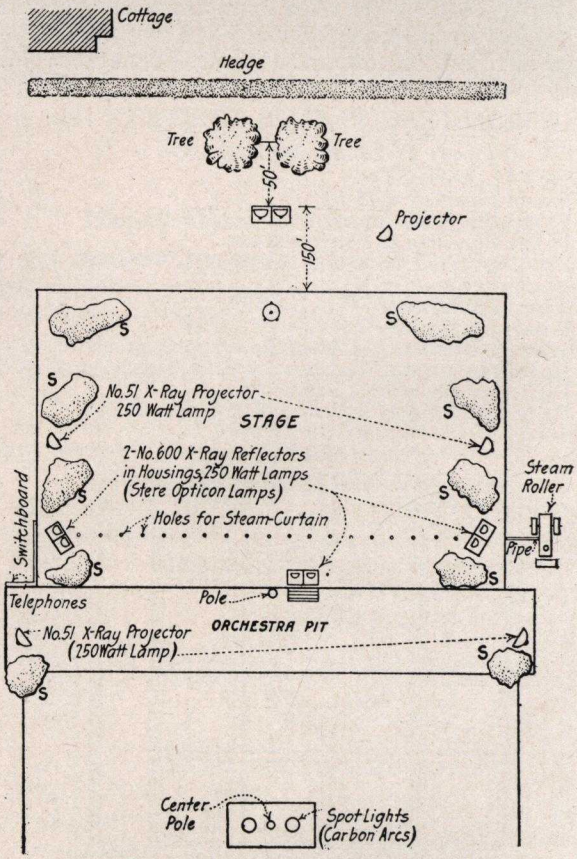


Fig. 280. Ground plan of outdoor stage illustrated above showing location of X-Ray reflectors and projectors.

By the skilful use of light, shade and color, the outdoor play may be made unusually attractive The use of flood lighting has increased the popularity of these night events.

The problem of lighting for outdoor plays is really divided into two distinct parts, lighting for the stage and lighting for the audience and involves such factors as the area to be flooded, distances of throw and the color effects desired.

For the stage, projected light is directed from various angles with units arranged to soften shadows as much as possible. Ordinarily, it is necessary to resort to side lights. By ingenious and careful placing the units can be entirely hidden from the audience. In some cases it is possible to build up a form of proscenium behind which the lights can be placed.

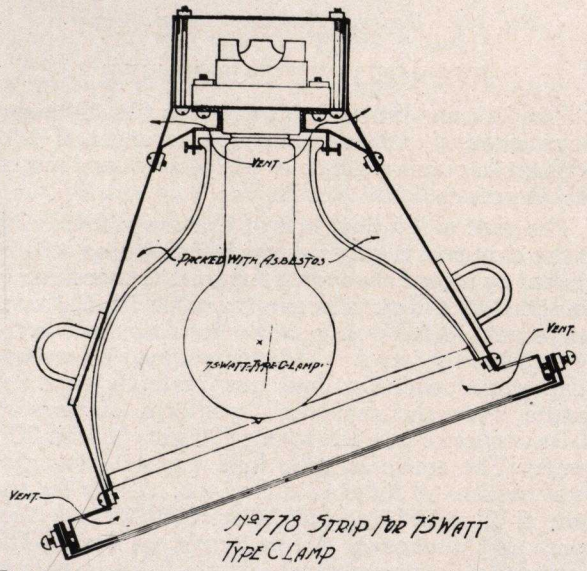


Fig. 281. Sectional view, typical X-Ray stage lighting strip.

Figures 279 and 280 show the details of the lighting arrangement for an amateur theatrical performance for the benefit of a charitable organization, given on the estate of Mr. James L. Breese at Southampton, Long Island. The entertainment was given in a large tent with an elevated stage at one end. The lighting effect with X-Ray equipment was worked out by Mr. Glenn Marston of New York. It is more fully described in the "Electrical Review" 1916.

CAFE COLOR LIGHTING

A typical lighting arrangement for cabarets and dance halls with X-Ray equipment is that installed in the Henderson's Cafe, Coney Island, where 132 No. 610 X-Ray reflectors placed in special housings, were employed. The housing in which the units were placed was arranged in such a manner that the three primary colors—red, green and blue—as well as straw colored mediums could be brought into

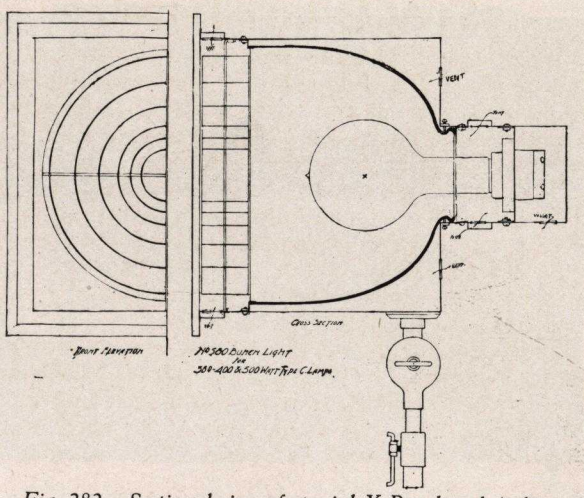


Fig. 282. Sectional view of special X-Ray bunch light.

service. All of the lights are on a dimmer system which enables the operator to obtain practically any degree of color.

The general lighting of the cafe was done with X-Ray No. E-65 reflectors in a special housing, also on a switch controlled from the main panel box.

X-Ray border lights, bunch lights and other types of stage lighting equipment are being used by many touring companies as well as in permanent installations. Producers find that this equipment results in more light, large current saving, better light direction, easy maintenance and great flexibility. Among the users are the Stuart Walker Co., Fox Amusement Co., William Gillette Co., Laurette Taylor Co., William Faversham, Oliver Morosco, etc.

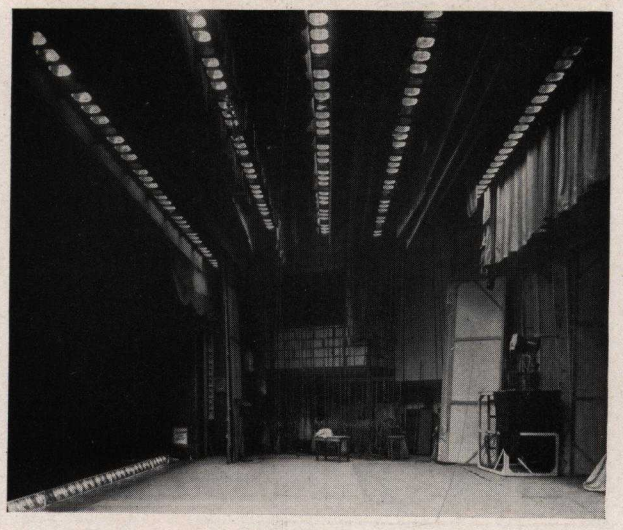


Fig. 283. A view on the stage, showing X-Ray Lighting Strips and Foot Lights—Aubudon Theatre, New York City, New York.

Fig. 284. Tennis Courts—Knickerbocker Field Club, Brooklyn, New York.

TENNIS COURTS

The illumination is so satisfactorily distributed by the equipment overhead that championship games have been played after dark on the courts reproduced above.

Tennis Court Lighting involves more than the mere illumination of the ground area occupied by the courts. The entire space above must be filled with illumination, so that flying balls are always in an atmosphere of light.

Suspended 30 feet from the ground above each of the three courts, are two X-Ray No. 54 "JUMBO" units, with 1500-watt lamps in each, and one X-Ray No. 580 reflector unit over the net, with a 500-watt Mazda "C" lamp. The reflectors are enclosed in metal housings. The hanging height indicated on the plan can, if necessary, be reduced to 25 feet from the ground; 30 feet, however, will result in a better distribution of light.

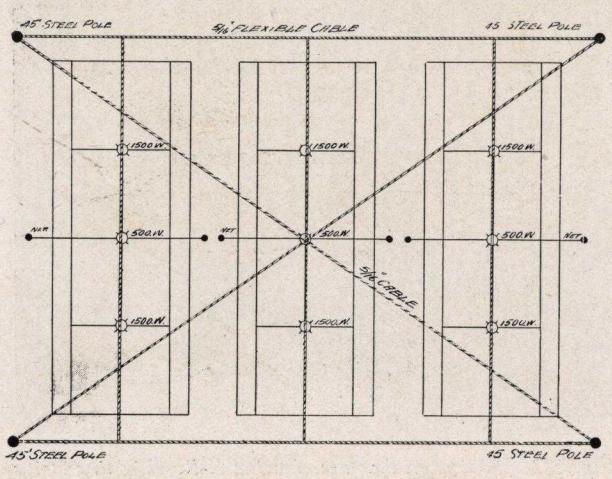


Fig. 285. Plan of Knickerbocker Field Club Tennis Courts

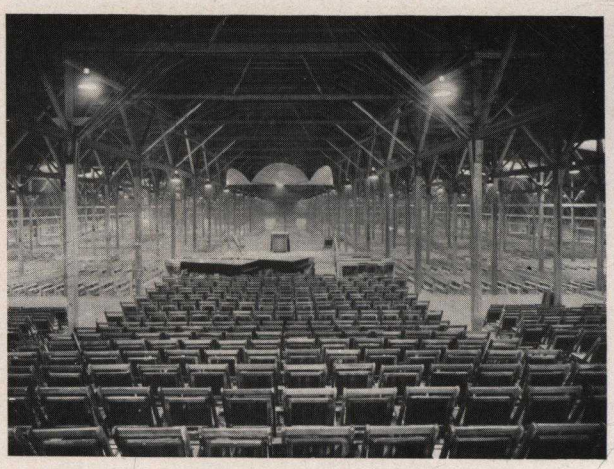


Fig. 286. Sunday Tabernacle, Chicago, Illinois.

EVANGELISTIC TABERNACLE

This "Gospel Barn" was erected in Chicago for a three months' campaign by the Evangelist, Mr. William A. Sunday. It covered 2½ acres and seated 13,244 persons

The general lighting, one of the most interesting of the electrical features of the building, was accomplished by means of pendant fixtures. These fixtures consisted of X-Ray reflectors No. 570 with 100 watt lamps, suspended from a center insulator by No. 14 twisted brewery cord. The open wiring was entirely adapted to conditions and was perfectly safe. A fixture over the preacher's platform carried an X-Ray reflector No. 580 with a 500 watt Mazda "C" lamp. The entire lighting load was 42 kilowatts; total number of lighting units, 466. Units for the general illumination were spaced about 16 feet apart and suspended 17 feet above the floor. The wattage expenditure was about 0.4 watts per square foot.

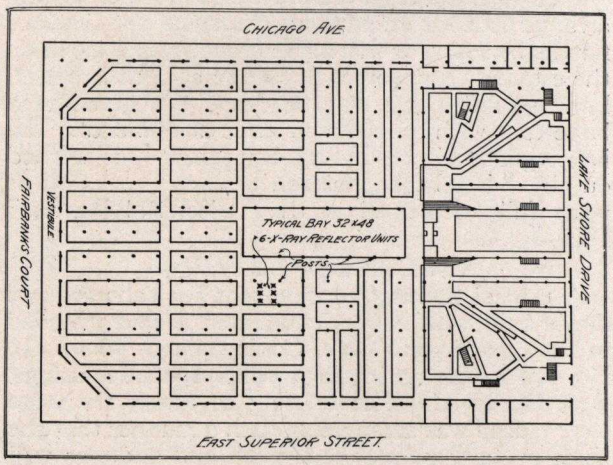


Fig. 287. Plan of Sunday Tabernacle, Chicago, Illinois.

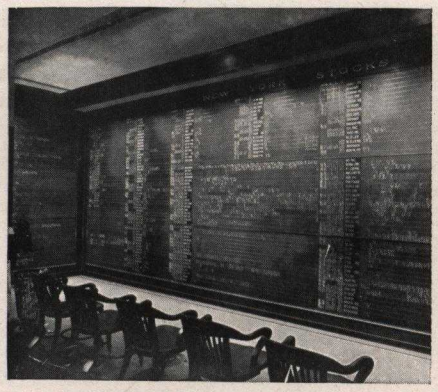


Fig. 288. Stock quotation board. Lighting by means of X-Ray Scoop reflectors.

STOCK QUOTATION BOARD

An even illumination is required over the entire surface of the board, so that figures and quotations may be as easily seen at the bottom of the board as at the top. Again the intensity of the illumination must be provided sufficient to enable the marks on the board to be seen in any part of the room.

The question of concealing the lamps is often simplified by building a false beam or apron behind which the lighting equipment is placed. X-Ray *Scoop* reflectors are used with 75 watt lamps and spaced about 2 feet apart.

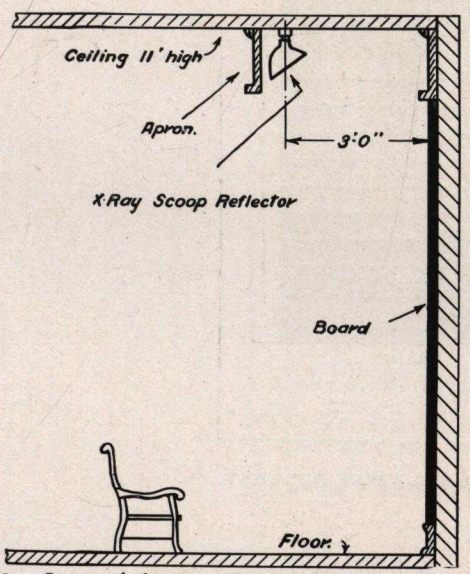


Fig. 289. Sectional diagram showing location of reflectors for stock quotation board lighting.

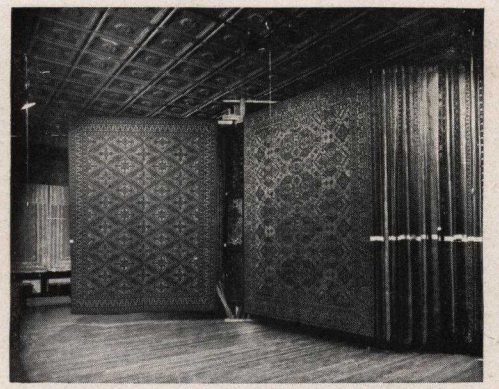


Fig. 290. Rug display rack, Scoop type X-Ray reflectors provide the illumination.

RUG AND CARPET DISPLAYS

The diagram below shows a standard lighting arrangement for a rug rack and carpet sample display, and can be relied upon to give satisfactory results. X-Ray *Scoop* reflectors are located 4 feet from the outer edge of the pivoted arms of the rack, 75 watt lamps are recommended.

If the rack is circular the lighting units can also be arranged in a concentric circle. For cases in which the rack pivots extend in a row along the wall the outlets should be placed parallel to the wall.

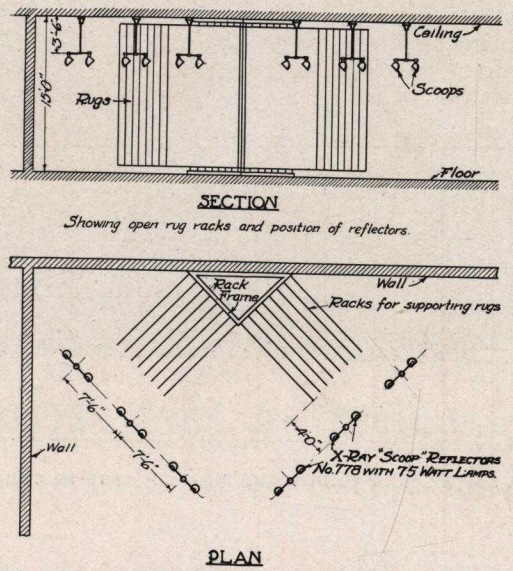
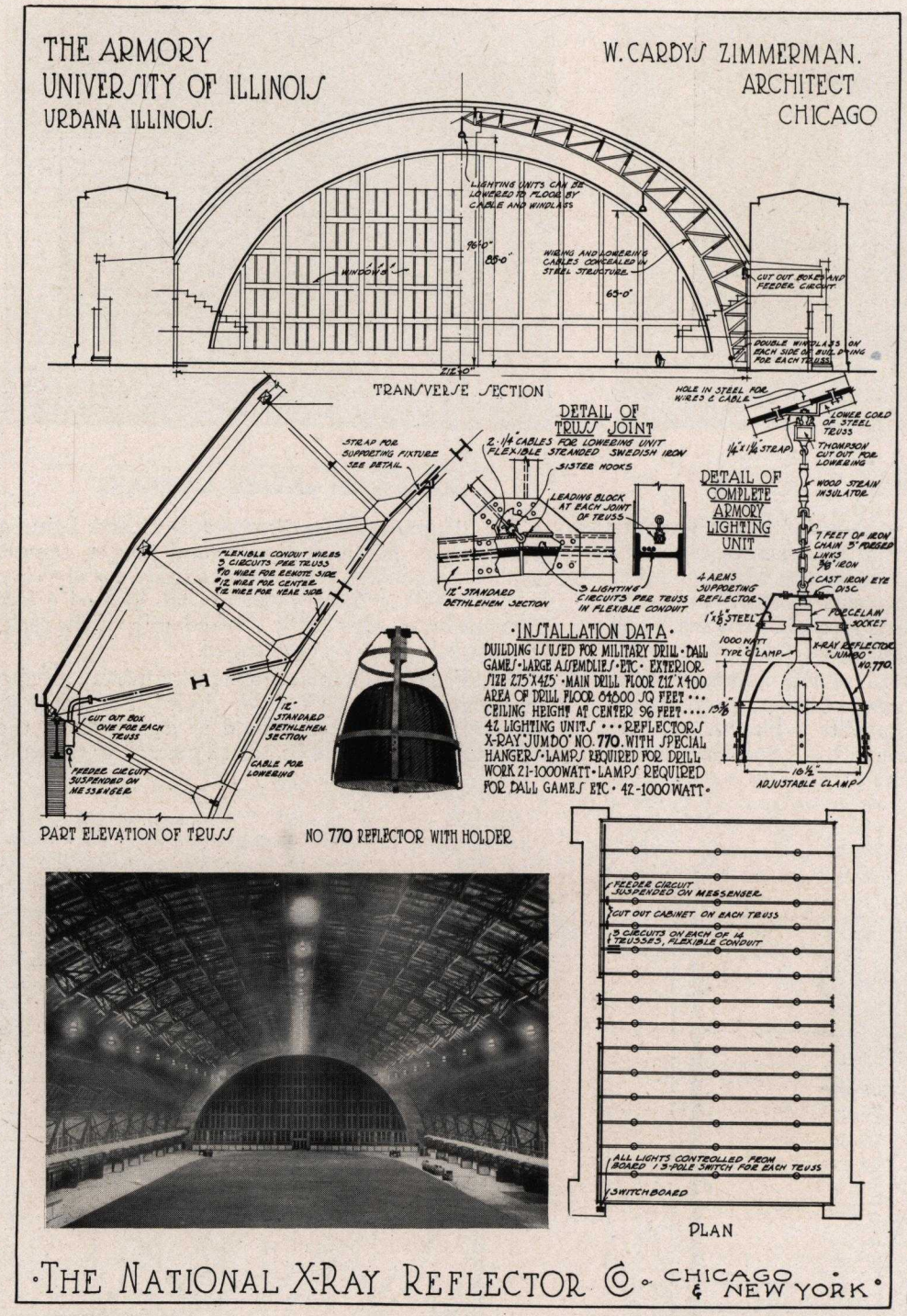


Fig. 291. Plan and elevation showing method of installing X-Ray reflectors for rug and carpet displays.



A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

ARMORIES

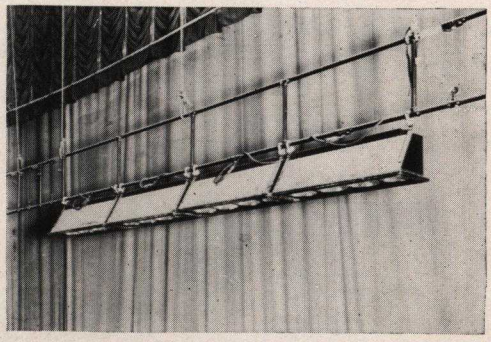
THE DRILL HALL OF AN ARMORY IS USUALLY A LARGE HIGH INTERIOR.

THE PROPER METHODS FOR LIGHTING THIS CLASS OF ROOM ARE DESCRIBED ON PAGE 139.

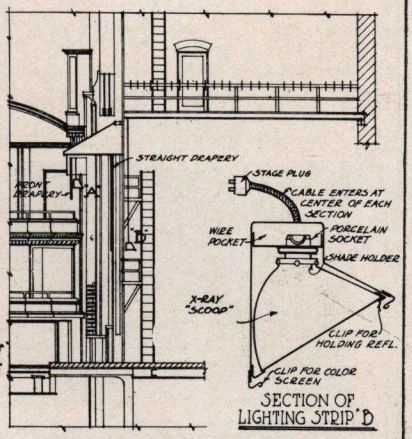
STAGES

ON PAGES 148 AND 149 A DISCUSSION IS GIVEN OF STAGE LIGHTING AND THE LIGHTING OF OUTDOOR PLAYS.

SEE ALSO THEATRE LIGHTING ON PAGES 64 AND 65.



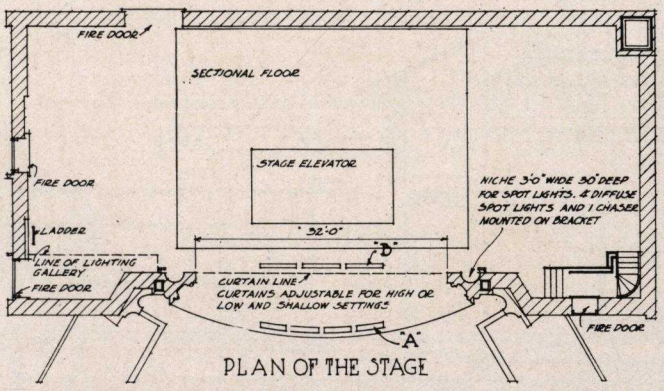
LIGHTING STRIP "A" SHOWING CONSTRUCTION OF PIPE HANGERS FEED WIRES AND METAL BOXES CONTAINING X-RAY REFLECTORS



SECTION OF LIGHTING STRIP "D"

THE BELASCO THEATRE
NEW YORK CITY
GEORGE KEISTER · ARCHITECT

SECTION THRO THE STAGE
SHOWING LOCATION OF METAL TROUGHS "A" & "B" ENCLOSING X-RAY REFLECTORS



PLAN OF THE STAGE

INSTALLATION DATA

SKETCHES SHOW LIGHTING ARRANGEMENTS FOR 2ND. ACT OF "THE BOOMERANG" PRODUCED BY DAVID BELASCO · NEW YORK. NO FOOTLIGHTS USED.

LIGHTING STRIP "A" BACK OF FRONT DRAPERY CONSISTS OF 4 UNITS, EACH WITH 4 X-RAY NO. 610 "JUPITER" REFLECTORS IN SPECIAL SHEET IRON BOXES WITH SLIDES FOR COLOR SCREENS. 1" IRON PIPE FRAMES. 100 WATT LAMPS USED. FEEDERS BROT THRU PIPE FRAMES. LIGHT CONTROLLED BY STAGE CABLES THRO SLIP CONNECTORS OR THEATRE PLUGS. SEE THE ILLUSTRATION ABOVE.

LIGHTING STRIP "B" BACK OF STRAIGHT DRAPERY BEHIND PROSCENIUM ARCH CONSISTS OF 3 SECTIONS EACH CONTAINING 3 X-RAY "SCOOP" NO. 778 REFLECTORS IN IRON HOODS. 60 WATT LAMPS. STRIP "B" SOMETIMES REPLACED BY A STRIP LIKE "A" FOR CERTAIN SETTINGS.

SPOTLIGHTS · SPECIAL · WITH 500 W. CONCEN. FILAMENT LAMPS AND SLIDES FOR COLOR SCREENS

STAGE SETTING FOR THE 2ND. ACT OF THE BOOMERANG SHOWING EFFECT OF THE LIGHTING

·THE NATIONAL X-RAY REFLECTOR CO.· CHICAGO & NEW YORK

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

MUSEUM OF FINE ARTS

MINNEAPOLIS MINN

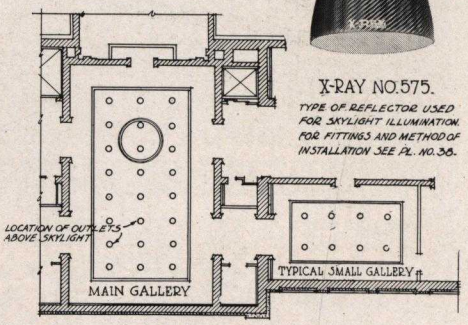
McKIM MEAD & WHITE · ARCHITECTS

NEW YORK

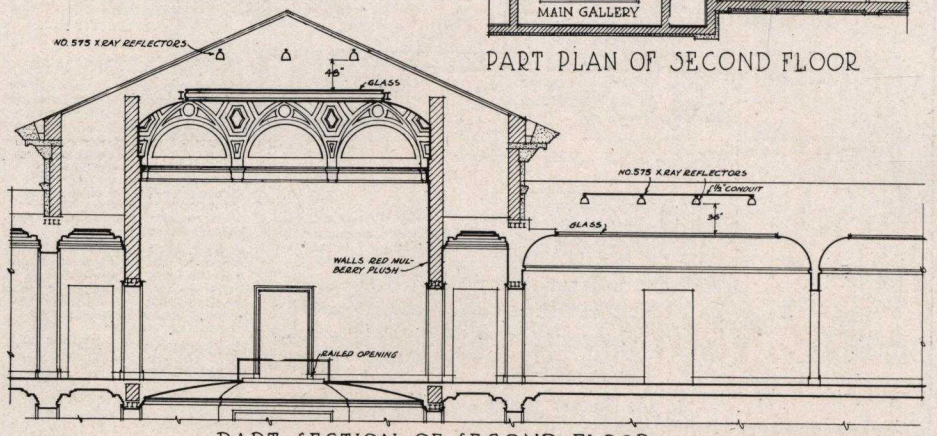
TYPICAL SMALL GALLERY

X-RAY NO.575.

TYPE OF REFLECTOR USED FOR SKYLIGHT ILLUMINATION. FOR FITTINGS AND METHOD OF INSTALLATION SEE PL. NO. 38.



PART PLAN OF SECOND FLOOR



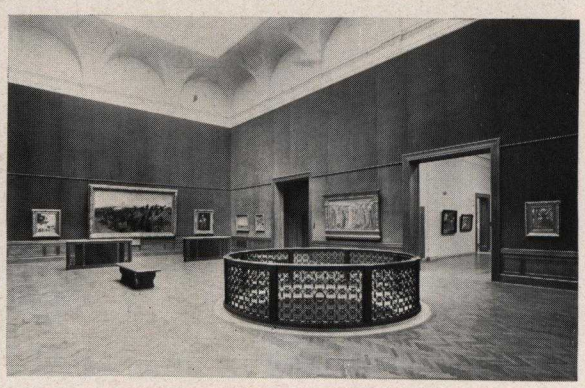
PART SECTION OF SECOND FLOOR

·INSTALLATION DATA·

MAIN GALLERY—36'-0"X60'-0" CEILING 36'-0"
FLOOR AREA 2160 SQUARE FEET
SKYLIGHT 24'-0"X48'-0"
24-NO. 575 X-RAY REFLECTORS USED WITH 200 WATT TYPE "C" LAMPS.
WATTS PER SQUARE FOOT 2.22
UNITS 48" ABOVE GLASS.
AVERAGE ILLUMINATION ABOUT 6 FT. CANDLES

SMALL GALLERY—24'-0"X36'-0" CEILING 14'-0"
FLOOR AREA 864 SQUARE FEET
SKYLIGHT 16'-0"X28'-0"
8-NO. 575 X-RAY REFLECTORS USED WITH 200 WATT TYPE "C" LAMPS.
WATTS PER SQUARE FOOT 1.85
UNITS 36" ABOVE GLASS.
AVERAGE ILLUMINATION ABOUT 5 FT. CANDLES.

X-RAY DIRECT LIGHTING REFLECTORS SUSPENDED ABOVE SKYLIGHTS SO AS TO PRODUCE EVEN BRIGHTNESS OF ILLUMINATION ON THE GLASS CEILING. GLASS USED FOR SKYLIGHTS, BELGIAN "MULTIFLORA" AND "SYENITE," THESE PROVIDE AMPLE DIFFUSION AND PREVENT VIEW OF EQUIPMENT ABOVE GLASS.



MAIN GALLERY OF THE MINNEAPOLIS ART MUSEUM

·THE NATIONAL X-RAY REFLECTOR CO.· CHICAGO & NEW YORK

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST

ART MUSEUMS

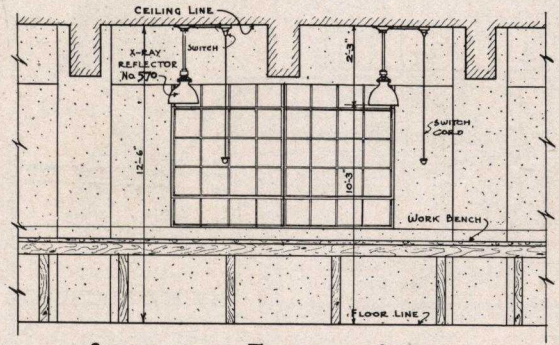
THE SKYLIGHT METHOD FOR ART MUSEUMS IS IDEAL; EXAMPLES ARE GIVEN ON PAGE 145.

THE REQUIREMENTS FOR INDIRECT LIGHTING IN ART GALLERIES ARE GIVEN IN TABLE No. 2, PAGE 34.

FACTORIES

THE LIGHTING OF INDUSTRIAL ESTABLISHMENTS IS DISCUSSED ON PAGES 129 TO 138.

INDIRECT LIGHTING FOR WORKROOMS IS ILLUSTRATED ON PAGES 56 AND 83.



SECTION OF TYPICAL BAY

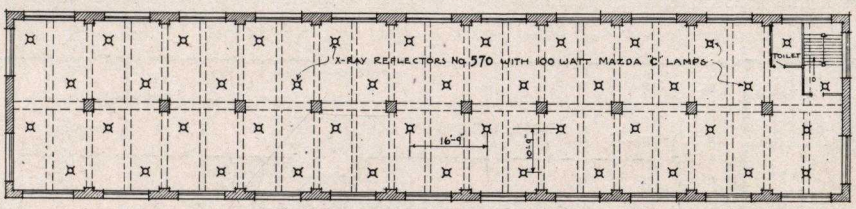
WISE BROTHERS BUILDING

BALTIMORE — MARYLAND

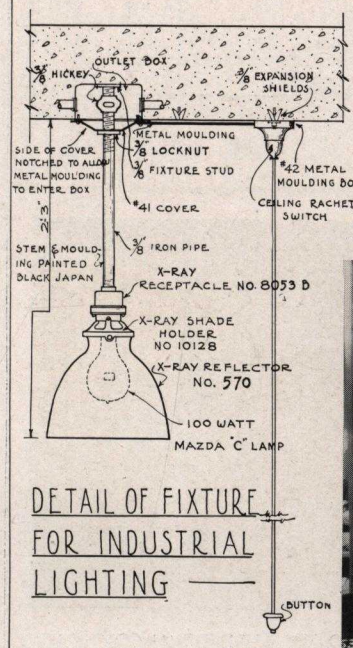
PARKER, THOMAS & RICE

— ARCHITECTS —

BALTIMORE — MARYLAND



PLAN OF TYPICAL FLOOR



DETAIL OF FIXTURE FOR INDUSTRIAL LIGHTING —

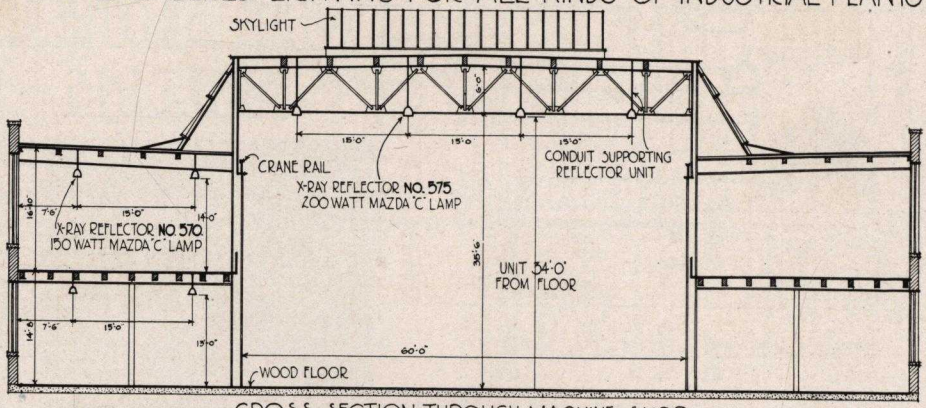
• INSTALLATION DATA •

ROOM 43'-0" X 184-3" — AREA 7923 SQ. FT - CEILING HEIGHT 12'-6"
CEILING & WALLS DOWN TO 4'-0" OF FLOOR ARE FLAT WHITE ON ROUGH CONCRETE SURFACE
TYPICAL BAY 21'-6" X 16'-9" — AREA 360 SQ. FT
TWO OUTLETS PER BAY WITH X-RAY REFLECTORS NO. 570
LAUNDRY DEPT. 150 W "C" - 2 DAYLIGHT LAMPS - .83 W. PER SQ. FT.
OTHER FLOORS 100 W MAZDA "C" LAMPS — .55 WATT PER SQ. FT
REFLECTORS 10'-3" FROM FLOOR

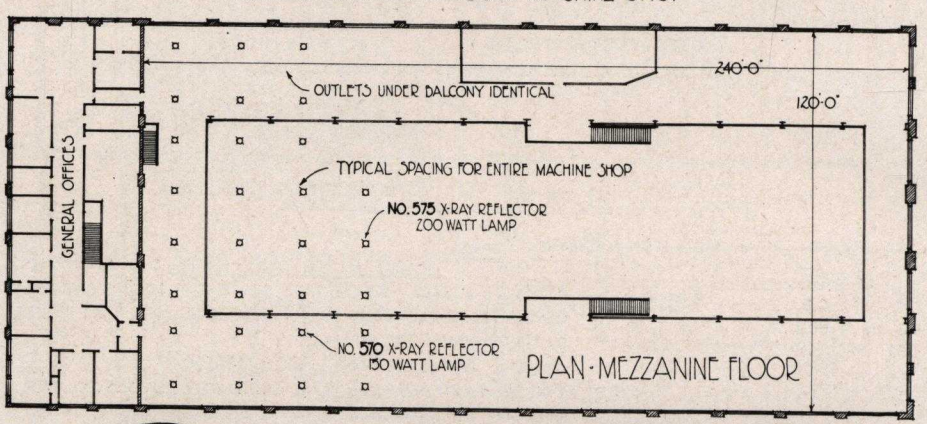
THE NATIONAL X-RAY REFLECTOR CO. · CHICAGO & NEW YORK

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

X-RAY ENGINEERED LIGHTING FOR ALL KINDS OF INDUSTRIAL PLANTS



CROSS SECTION THROUGH MACHINE SHOP



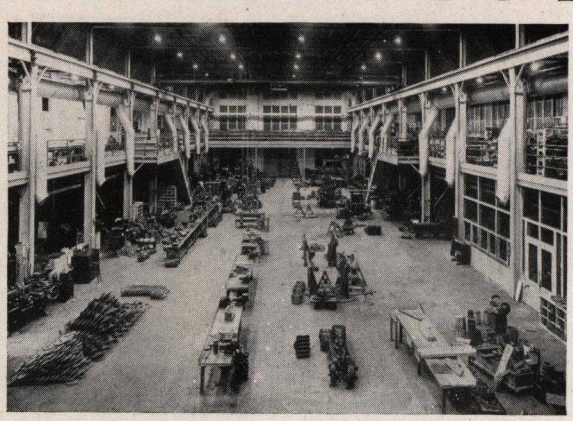
PLAN - MEZZANINE FLOOR

NO. 575 X-RAY REFLECTOR

A DEEP BOWL TYPE OF REFLECTOR FOR GENERAL ILLUMINATION IN INDUSTRIAL PLANTS. HIDES THE LAMP AND GIVES COMFORTABLE WELL DIFFUSED LIGHT ON ALL THE WORK.

GENERAL NOTES

SHOP SPACES - TYPICAL BAY 20X60 - 1200 SQ. FT.
SIDE AREA 20X28' 560 SQ. FT.
REFLECTORS AND LAMPS - CENTER
X-RAY REFLECTOR NO. 575 WITH 200 WATT MAZDAC LAMP
REFLECTORS AND LAMPS - SIDE AREA
X-RAY REFLECTOR NO. 570 WITH 150 WATT MAZDAC LAMP
WATTS PER SQ. FT. CENTER AREA 0.67
SIDE AREA 0.34
OFFICE SPACES ARE LIGHTED THROUGHOUT WITH X-RAY INDIRECT ILLUMINATION.



NIGHT VIEW OF MACHINE SHOP - THE PYLE NATIONAL CO - CHICAGO

DAVIDSON AND WEISS ARCHITECTS CHICAGO

THIS IS NOT A FLASHLIGHT PICTURE

JOHN D SMALL CONSULTING ENGINEER CHICAGO

FACTORIES

THE LIGHTING OF INDUSTRIAL ESTABLISHMENTS IS DISCUSSED ON PAGES 129 TO 138.

INDIRECT LIGHTING FOR WORKROOMS IS ILLUSTRATED ON PAGES 56 AND 83.

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

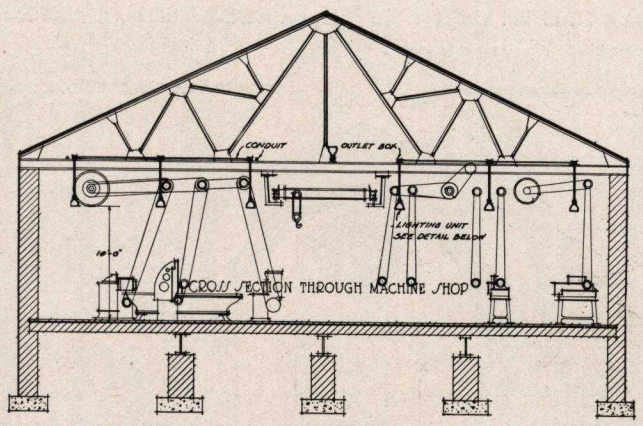
MACHINE SHOPS

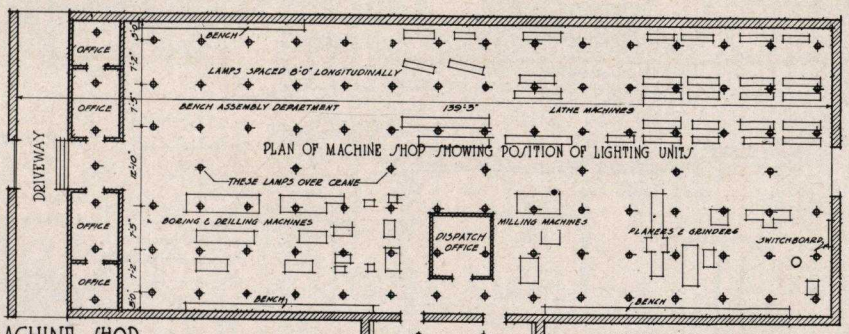
THE MANY CONDITIONS THAT INFLUENCE THE SELECTION OF LIGHTING EQUIPMENT FOR MACHINE SHOPS ARE GIVEN, WITH A PLAN AND COMPLETE DATA, ON PAGE 130.

NO. 535
FOR 40-60 OR 75 WATT LAMPS

NO. 570
FOR 100 WATT LAMPS

THESE REFLECTORS ARE DESIGNED ESPECIALLY FOR MACHINE SHOP LIGHTING. THEY HIDE THE LAMP AND PROVIDE CORRECTLY DISTRIBUTED ILLUMINATION.

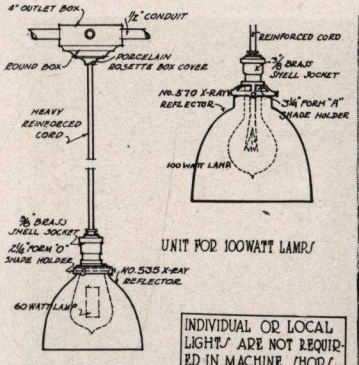




MACHINE SHOP ··
THE COLLEGE OF ENGINEERING ··
UNIVERSITY OF ILLINOIS ··
URBANA ILLINOIS ··

INSTALLATION DATA

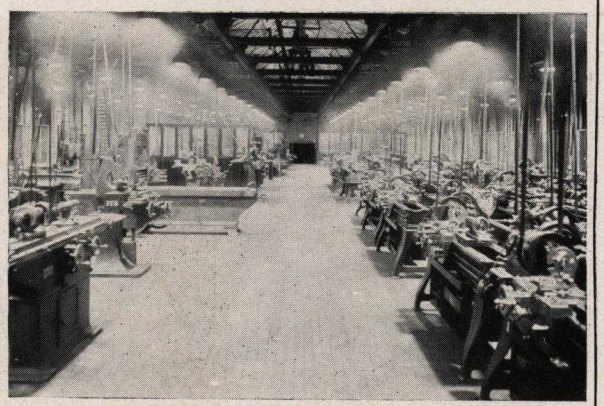
SIZE OF MACHINE SHOP 48'-0"X130'-0" · TOOL ROOM 20'X26' OUTLETS SPACED 8'-0" APART · TYPE OF REFLECTOR NO. 535 X-RAY · SIZE OF LAMP 60 WATT · NO. OF REFLECTORS USED 117 · HEIGHT ABOVE FL. 10'-0" WATTS PER SQ. FT. 1.0 · AVERAGE INTENSITY OF ILLUMINATION 5 FT. CANDLES 7 REFLECTORS INVERTED OVER CRANE SPAN NO. 535 WITH 60 W. LAMPS



UNIT FOR 100 WATT LAMPS

TYPE OF 60 WATT LIGHTING UNIT FOR MACHINE SHOPS

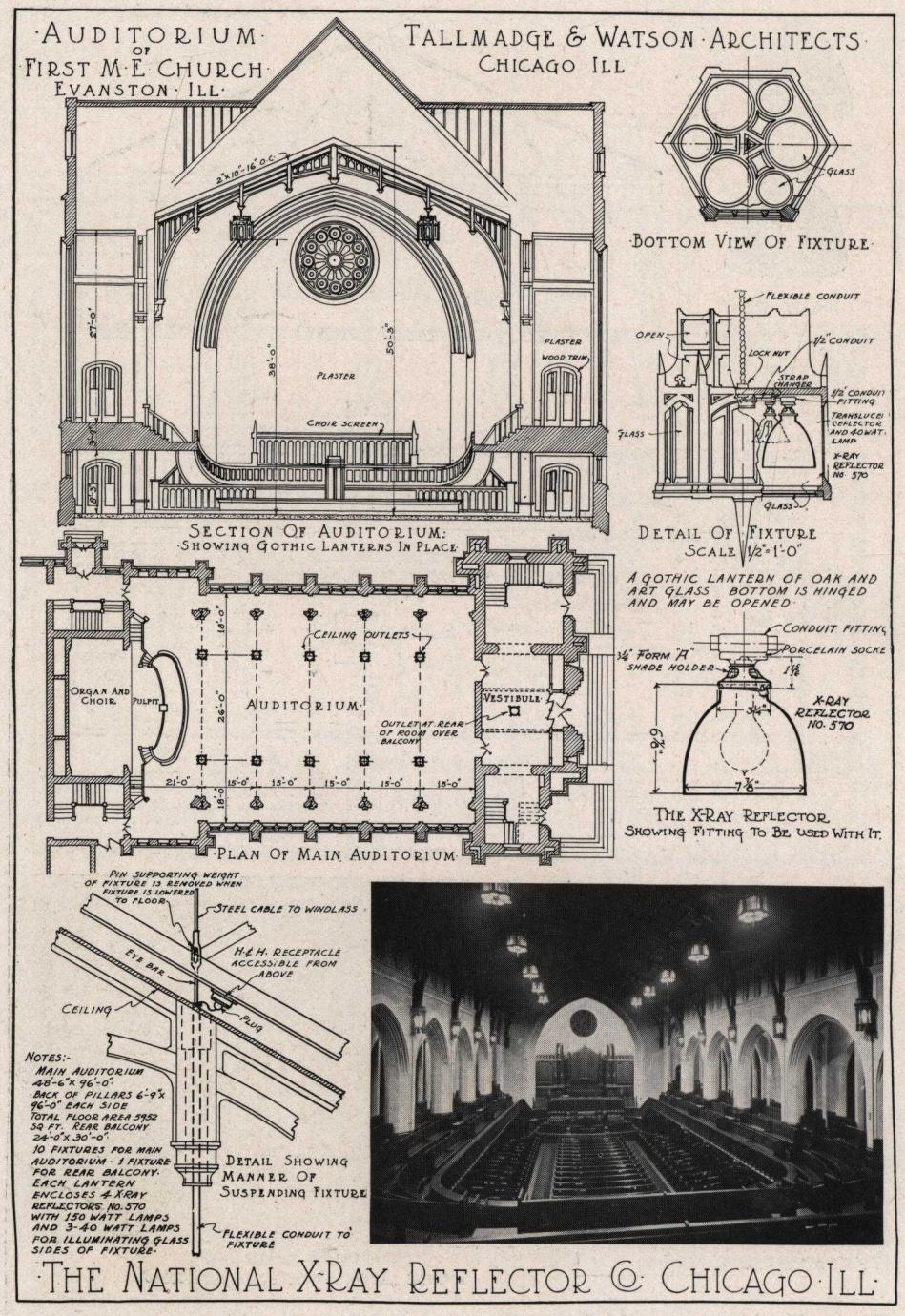
INDIVIDUAL OR LOCAL LIGHTS ARE NOT REQUIRED IN MACHINE SHOPS LIGHTED WITH A PROPERLY DESIGNED OVERHEAD SYSTEM.



NIGHT VIEW OF MACHINE SHOP SHOWING ILLUMINATION WITH X-RAY REFLECTORS

·THE NATIONAL X-RAY REFLECTOR ©· CHICAGO·ILL·

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.



A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

CHURCHES

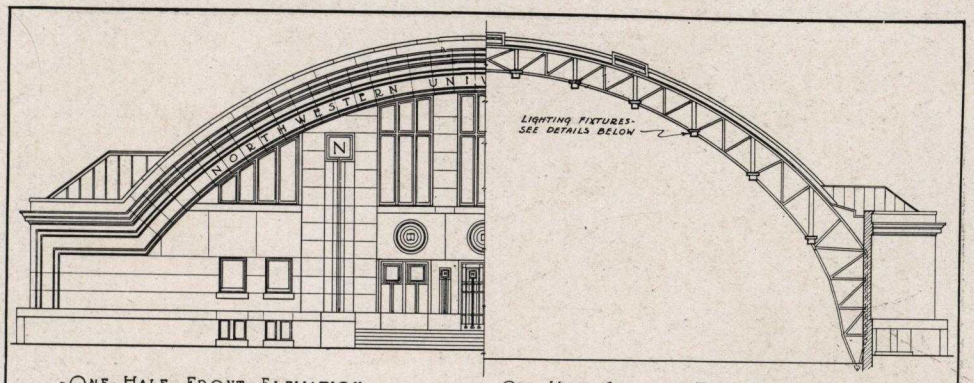
SOME DARK-CEILINGED CHURCHES ARE NOT SUITED TO INDIRECT ILLUMINATION AND DIRECT LIGHTING METHODS MUST BE RESORTED TO.

INDIRECT LIGHTING FOR CHURCHES IS TAKEN UP ON PAGE 59.

GYMNASIUMS

THE LIGHTING OF GYMNASIUMS AND THE PROPER TYPE OF FIXTURE ARE DISCUSSED ON PAGE 140.

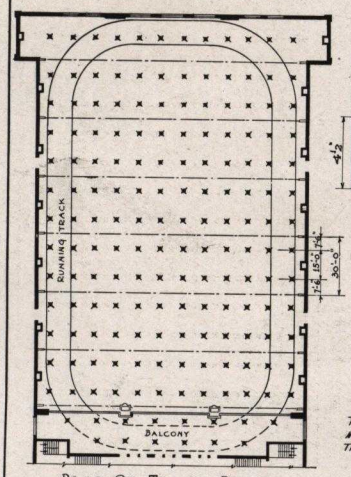
FOR LARGE GYMNASIUMS THE METHODS FOR ARMORY LIGHTING ON PAGE 139 CAN BE EMPLOYED.



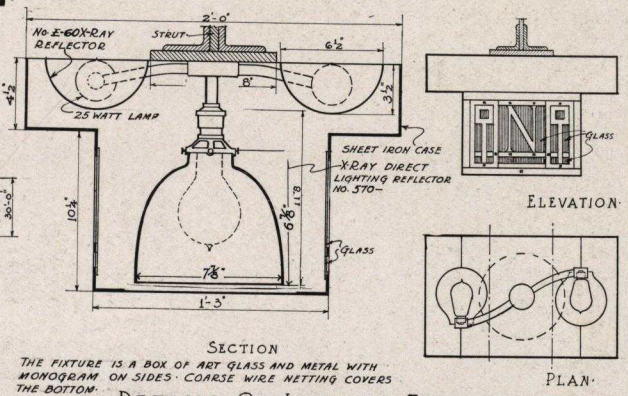
-ONE-HALF FRONT ELEVATION -

-ONE HALF SECTION THRU TRACK ROOM-

THIS LARGE ROOM FOR INDOOR SPORTS IS LIGHTED BY X-RAY BEEHIVE REFLECTORS WITH 100 WATT LAMPS. THE SAME LIGHTING ARRANGEMENTS CAN BE APPLIED TO ARMORIES, COLISEUMS, ERECTING SHOPS, ETC.



PLAN OF TRACK ROOM



SECTION

THE FIXTURE IS A BOX OF ART GLASS AND METAL WITH MONOGRAM ON SIDES. COARSE WIRE NETTING COVERS THE BOTTOM.

DETAILS OF LIGHTING FIXTURE

THE LOCATION OF THE LIGHTING FIXTURES IS INDICATED.

WATTAGE CONSUMED IS ABOUT .65 WATTS PER SQ.FT. FOR THE DIRECT LIGHTING. ADDITION OF INDIRECT LIGHTING FEATURE BRINGS TOTAL WATTAGE TO ABOUT 1 WATT PER SQ.FT.

NORTHWESTERN UNIVERSITY GYMNASIUM.

GEO. W. MAHER ARCHITECT
CHICAGO. ILLINOIS

THE CEILING IS LIGHTED BY X-RAY REFLECTORS NO. E-60 POINTED UPWARD. TWO 25 WATT LAMPS WITH THESE REFLECTORS ARE PLACED IN THE TOP OF EACH FIXTURE.

THE NATIONAL X-RAY REFLECTOR CO. CHICAGO ILL.

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

Fig. 292. Show Windows—Z. L. White Company, Columbus, Ohio.

XI SHOW WINDOW LIGHTING

GENERAL PRINCIPLES—EQUIPMENT FOR SHOW WINDOW LIGHTING

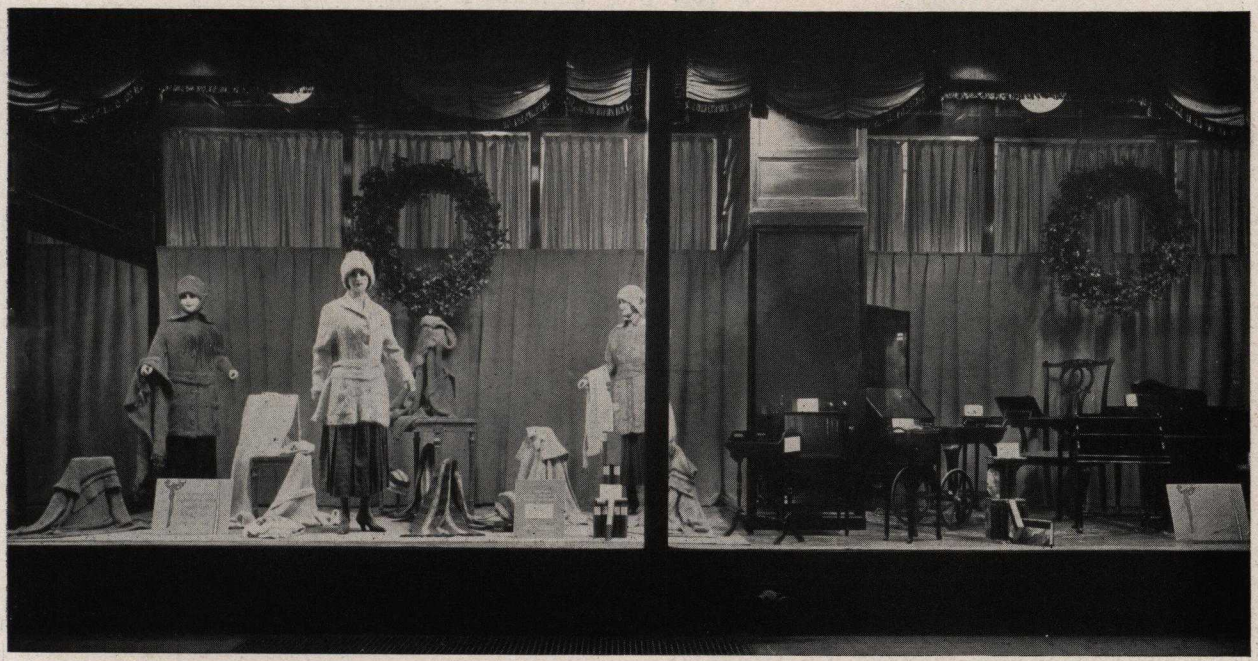


Fig. 293. Show Windows, Carson Pirie Scott & Co., Chicago, Ill.

THE show window is equal in importance to the salesman behind the counter. It is an index of what the store contains. It is the best introduction to the prospective customer, a magnet which will draw the passerby into the store. Great sums of money have therefore of recent years been expended for elaborate backgrounds, huge pieces of plate glass, handsome display fixtures, window dressing accessories and lighting equipment, in the effort to make the show window the supreme attraction and the big advertisement.

Window lighting is as old as the shop window, and the methods employed for the illumination of the displays have advanced along with the developments in the prominence and importance of the show window itself.

It is only a few decades ago that candles and oil lamps were used as a source of illumination for the night-lighted shop window. These were soon succeeded by gas jets and mantle lights and finally when the electric incandescent lamps came into general use, a new era for window lighting began.

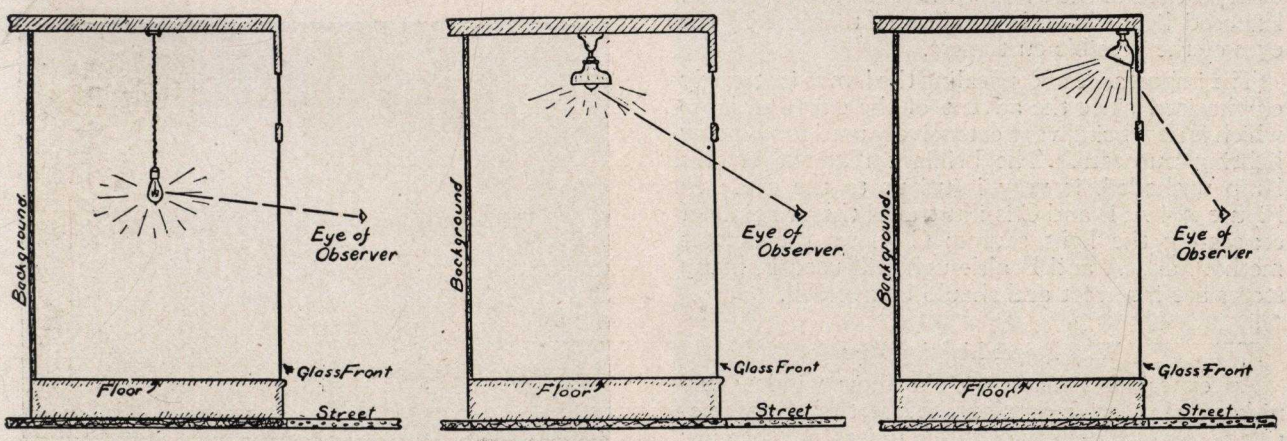


Fig. 294. Diagrams illustrating the correct and incorrect principles in show window lighting.

Fig. 295. Dim light does not attract. Bright lights from hidden lamps draw trade. Glare hurts eye-sight.

These lamps are easy to apply and because of their brilliancy and misapplication, the science of correct show window lighting began to develop rapidly. The window lighting unit now, instead of shedding only a certain amount of radiance, is made to serve a definite purpose, to actually control the light to meet the demands of the merchant who can by careful and intelligent use of the light cause his window to stand out at night attractively and even more so than it does during the day.

Waste of light has been one of the most common defects in the past. Too many lights have been used and these incorrectly, located or placed in shades or reflectors of improper shape. In many cases half the light paid for has been wasted on the sidewalk or in portions of the window where it was not needed. Exposed lights have been allowed to blaze in the eyes of the possible customers.

The importance of concealing the lamps is strongly emphasized since the advent of the gas filled lamp which is now being very extensively used for window lighting purposes. The brilliant filament of this lamp unshaded, is very injurious to the eye. In Figure 294 A, B and C is illustrated the principle of concealing the light source; C shows the correct method, and A and B although still used in many stores are incorrect and should be avoided.

Why Proper Lighting Pays

An experiment made with a show window furnishes quantitative data on the effect of the attractive power of hiding the lighting units from the view of the passerby. This window had an original equipment consisting of a fairly expensive lighting fixture carrying a number of opal glass shades which were suspended in full view. By actual count extending over four nights, this window attracted the attention of about 12% of the persons passing it. The lighting equipment was then entirely changed; a reflector better suited for the window was installed and located correctly in such a position that the lamp was not visible from outside the window. The re-count that was made on four successive nights indicate that 72% of the passersby were attracted—an increase of 500%. In other words, the merchant installing the up-to-date and rational system of lighting increased five to one his chances for making his window count in increasing his sales.

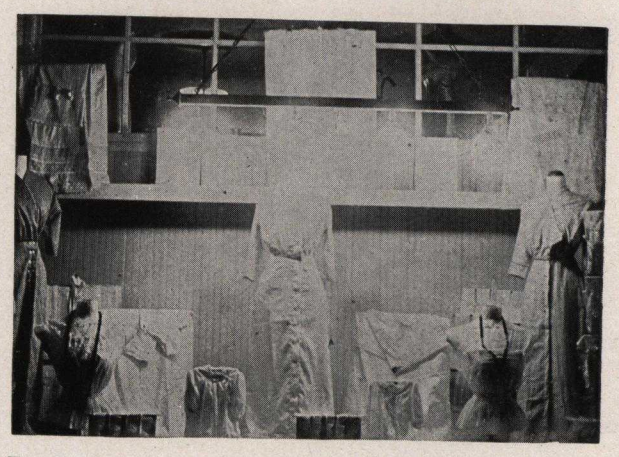


Fig. 296. Sample of a poor window lighting method. It is still in use in many shop windows.

The light which falls upon the goods in the show window should come from above and from the front. The carrying out of this principle insures that the shadows will be correct. With the light coming from directly above, as in the case when units are installed as in Figure 294B, long unnatural shadows will fall across the articles displayed in the window.

The intensity of illumination that is required in the show window depends upon several conditions, such as the character of the goods on display, the location of the store, the kind of background and decorations used, as well as the intensity of the street illumination. Dark goods obviously require a brighter illumination than light goods, which naturally reflect a greater proportion of the light that falls upon them. The store in a small city or outlying city street can be attractively lighted with a much less intensity than is required for the prominent windows of the large metropolis. In many cases it is necessary to increase the intensity of window lighting, because of the competition of a bright street illumination.

Dim light lacks "punch." People pass such windows without noticing them because there is nothing to attract the eye. Glaring light hurts eye-sight. A brilliant light attracts attention to itself instead of to the goods in the window. Bright light from concealed sources commands attention—displays the goods beautifully—makes seeing easy and holds the crowds.

Importance of Correct Reflectors

Keen competition demands the use of the most efficient equipment in window lighting, as well as in other departments of a commercial enterprise.

There are hundreds of ways to light show windows and the market offers many appliances for the purpose. Each show window presents a distinct problem for the merchant and lighting man. To illustrate the importance of using the correct shape of reflector of the most efficient type it has often been found that by replacing old equipment by properly designed reflectors, the light on the goods can easily be doubled without any increase in current. In other words, it is common to find losses of thirty to fifty per cent in a window lighting installation. These losses are mainly due to the inefficiency of the reflectors used, poor design or improper shaped reflector, or to the use of reflectors which are not intended or suited to window lighting.

The only reflectors to use for show windows, are those which have been designed especially for this class of lighting. Present practice in show window illumination indicates that the units for one lamp only are to be preferred to reflectors with more than one lamp—such as, troughs, clusters, etc. The individual reflector allows absolute control of the light

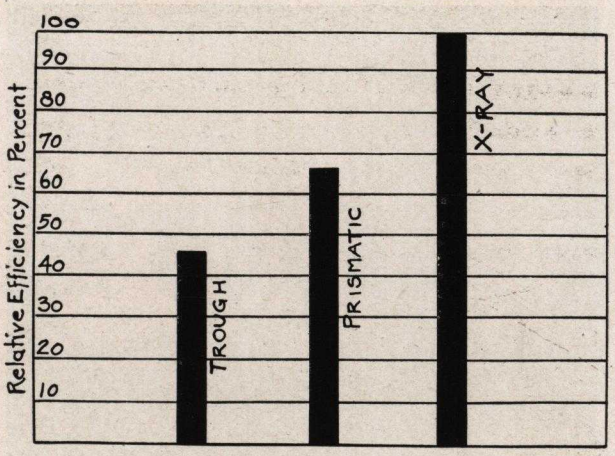


Fig. 297. Chart giving the results of an authentic test of various types of show window lighting reflectors.

given off by the lamp and delivers it on to the goods within certain definite angles, thus avoiding a waste of light on the sidewalk and on the window top.

SHOW WINDOW REFLECTORS CLASSIFIED

Show windows can be classified in two ways. First, in accordance with their general dimensions —height and depth, and second with reference to the nature of their background.

We find show windows of many shapes and sizes. High windows, low windows, shallow, deep, square, L-shaped, shallow boxed-in windows and those with open or glass background, windows with

Fig. 298. A type of show window with a solid background. Honolulu Hardware Store, Honolulu, T. H.

Fig. 299. A type of show window with a partially solid background, upper portion of clear glass for admitting daylight into the store.
Jordan Marsh Co., Boston, Mass.

Fig. 300. A type of show window having an all-glass background, requiring a special design of reflector.
Winter's Jewelry Store, Minneapolis, Minn.

low displays, high trims, etc. Yet all of these conditions can be properly and economically taken care of by the lighting devices now available. The X-Ray line covers the field of show window lighting completely. Each individual reflector is suited to a particular type of window. It is vitally important that the proper reflector always be used.

REFLECTORS FOR SHOW WINDOW LIGHTING

Reflectors shown on the opposite page are designed to take care of the many requirements of show window lighting.

The Jove No. 600 for a 100 watt lamp is intended for large windows of usual proportions, those whose height is one to one and one-half times their depth, and especially windows with solid backgrounds.

The Jupiter No. 610 for a 100 watt lamp is a more concentrating type of reflector than the Jove and is used for windows whose height equals about twice their depth. It is the proper reflector for windows having an open or glass background, and its special design prevents the light being thrown back into the store.

The Scoop No. 778 for the 75 watt lamp is for windows of average size and whose depth is about equal to the height and where the trim is made high in the back of the window.

The Hood No. 731 for the 75 watt lamp is designed to light windows which are shallow from front glass to background. This reflector concentrates the light in a manner similar to the Jupiter.

The curves given with each reflector show how the light is distributed from each type.

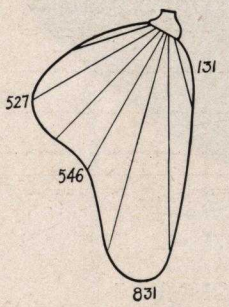
Fig. 301. General type of show window having a background entirely open, or without background.
Freeman Bros. Grocery Store, Chicago, Ill.

REFLECTORS FOR SHOW WINDOW LIGHTING

The "Jove"
No. 600

For 100-watt Mazda "C" lamp.

Width, 10 inches.
Depth, front to back, 9 13/16 inches.
Height, including neck 7 5/8 inches.
Holder, 3 1/4 inches, Form "A."

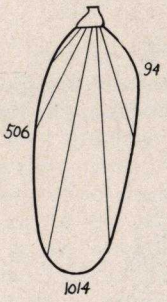


Distribution of light with 100-watt lamp.

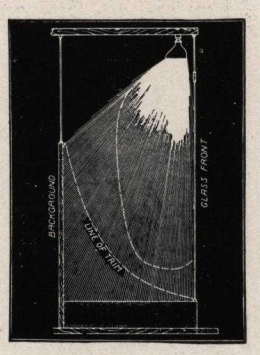
The "Jupiter"
No. 610

For 100-watt Mazda "C" lamp.

Width, 10 inches.
Depth, front to back, 10 1/8 inches.
Height, including neck, 7 5/8 inches.
Holder, 3 1/4 inches, Form "A."



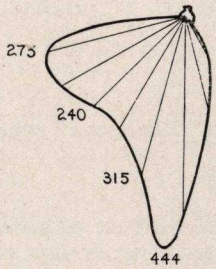
Distribution of light with 100-watt lamp.



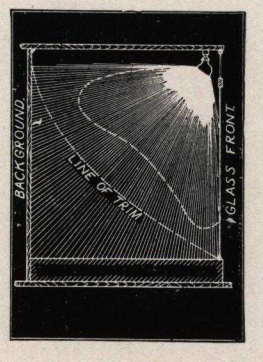
The "Scoop"
No. 778

For 75-watt Mazda "C" lamp.

Width, 7 1/16 inches.
Depth, front to back, 6 7/8 inches.
Height, including neck, 6 3/16 inches.
Holder, 2 1/4 inches, Form "O."



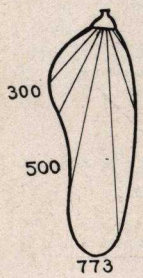
Distribution of light with 75-watt lamp.



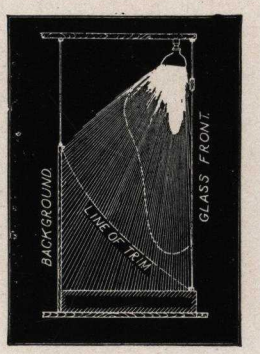
The "Hood"
No. 731

For 75-watt Mazda "C" lamp.

Width, 8 7/8 inches.
Depth, front to back, 8 7/8 inches.
Height, including neck, 6 3/16 inches.
Holder, 2 1/4 inches, Form "H."



Distribution of light with 75-watt lamp.



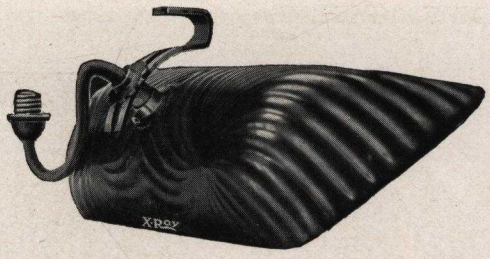


Fig. 302. "Poke Bonnet" Reflector No. 750.

THE "POKE BONNET"

No 750

For 25-, 40-, 50-, and 60-watt Mazda "B" Lamps

Length, 14 inches.
Depth, 7½ inches.
Special adjustable holder.

The "Poke Bonnet" reflector is designed for low, deep windows. It is fitted with a twin socket and, therefore, uses two lamps burning in a hori-

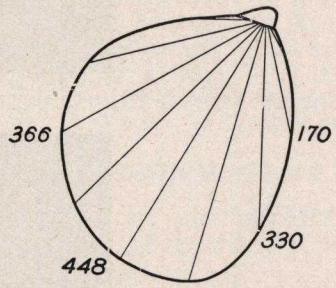


Fig. 303. Distribution of light from the "Poke Bonnet" reflector with two 40-watt Mazda "B" lamps.

zontal position. It is equipped with an adjusting fork. A 6-inch window drape, molding, or sign will hide this reflector.

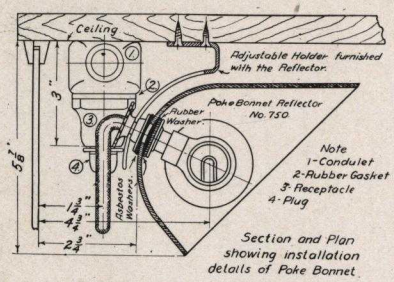


Fig. 304. The correct method of installing "Poke Bonnet" reflector.

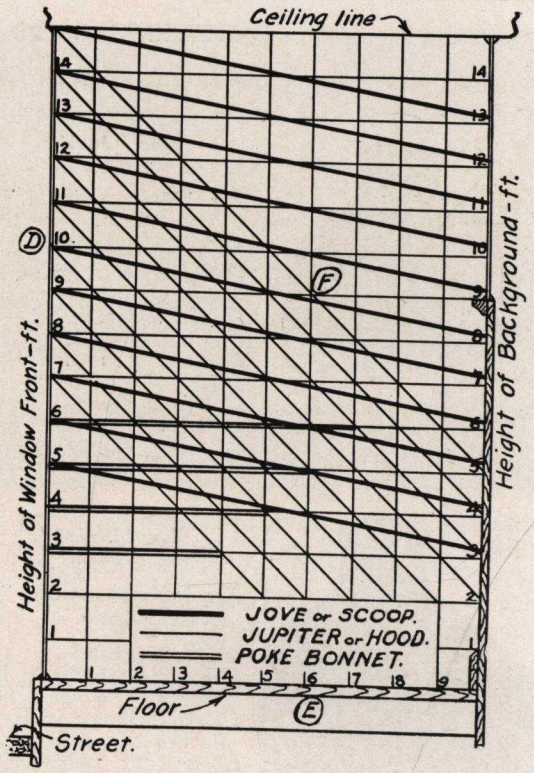


Fig. 305. Chart enabling the selection of show window reflectors for various types of windows, to be easily made.

SELECTION OF EQUIPMENT

The accompanying chart makes easy the selection of the correct reflector for any type of window. An example or two will demonstrate how simple it is to apply the chart to window lighting problems. To start with, knowledge of three things is necessary: the height the reflectors are to be placed, depth of window from glass to background and height and nature of the window background.

Example

For instance a window is 10 feet high, 6 feet deep and 9-foot trim.

Referring to the chart, locate 10 feet on the left hand vertical scale corresponding to the window front and designated "D;" 6 feet on the lower horizontal scale corresponding with the floor line and designated "E;" from "E" move straight upward to 9 feet, the height of trim, designated "F." Note that the points "E" and "F" are practically connected by one of the heavy black lines. The key at the bottom of the chart indicates that the Jove or Scoop reflector is required for this window. As this is a large window, use the Jove reflector.

Example

Dimensions of window 8 feet high, 5 feet deep, 4-foot trim.

Locate the height, 8 feet, the depth, 5 feet, and the height of trim, 4 feet. The line connecting the point at the height of 8 feet with the point at height of trim 4 feet, indicated on vertical at 5-foot depth, practically coincides with the light black line which indicates a Jupiter or Hood reflector is required for this window. As this is a comparatively small window, use the Hood reflector.

SPACING OF REFLECTORS

The number of reflectors to use is optional with the merchant. No set rule can be established. It is influenced by a number of conditions, such as the brightness in neighboring windows, the intensity of street illumination, kind of goods on display, color and nature of the background in the window, and largely by the extent of the merchant's realization of the advertising and selling value of bright windows.

The closer the reflectors are spaced the brighter the window becomes and vice versa.

In average installations the spacing or distance from center to center for these reflectors is about as follows:

Jupiter 100-watt Mazda "C" lamp	24 inches
Jove 100-watt Mazda "C" lamp .	24 inches
Scoop 75-watt Mazda "C" lamp .	18 inches
Hood 75-watt Mazda "C" lamp .	18 inches
Poke Bonnet 2 60-watt Mazda "B" lamps	36 inches

For show windows in small cities, the spacing or distance between the reflectors may be increased to 30 inches for the Jove and Jupiter and to 24 inches for the Scoop and Hood. The spacing for the Poke Bonnet can also be increased to 40 inches.

The above, of course, are to be understood to be the average spacings and are subject to variations. If the windows adjoining are dim, the show window will require less light than if the near by windows are brightly illuminated. The bigger the city, the keener the competition among merchants the brighter must be the show window.

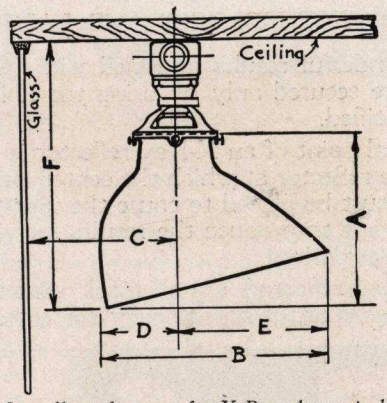


Fig. 306. Installing diagram for X-Ray show window reflectors, dimensions given in table below.

INSTALLING INFORMATION

The diagram above enables anyone to easily install X-Ray reflectors. It shows the space occupied by the various reflectors at the top of the window.

The dimension "C" to the center of the socket may be varied somewhat depending upon the construction of the window front. The dimension as given in the table is ample to allow for cleaning the window without removing the reflector and for placing of a drape or shade between the reflector and the glass.

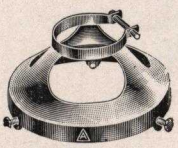
Reflector	A	B	C	D	E	F	Wdth	Size of Holder
Jupiter.....	7 5/8"	10 1/8"	6 1/4"	3 7/8"	6 1/4"	11 1/4"	10"	3 1/4" A
Jove.....	7 5/8"	9 13/16"	6 1/4"	3 5/8"	6 3/16"	11 1/4"	10"	3 1/4" A
Scoop.....	6 5/16"	6 11/16"	5 1/2"	2" 23/32	3 31/32"	9 7/16"	7 7/16"	2 1/4" O
Hood.....	6 3/16"	8 7/8"	6"	3 3/16"	5 11/16"	9 13/16"	8 7/8"	2 1/4" H

Fig. 307. Chart giving dimensions of window reflectors.

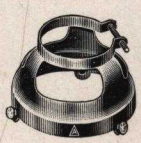
Shade Holders

To avoid trouble in installing reflectors and to be sure that the lamp is held in the proper position follow the instructions regarding shade holders given on page 118.

2¼ in. Form O.



2¼ in. Form H,



3¼ in. Form A

Fig 308. Standard Types of Shade holders

CORRECT HOLDERS AND LAMPS

The wonderful results obtained with X-Ray reflectors are secured only by using the holders and lamps specified.

The focal point of an X-Ray reflector is the position in the reflector at which the center of the lamp filament must be placed to cause the unit to reflect the light rays to produce the results for which the reflector was desired.

All X-Ray reflectors are all focal point reflectors —in other words, of scientifically correct design.

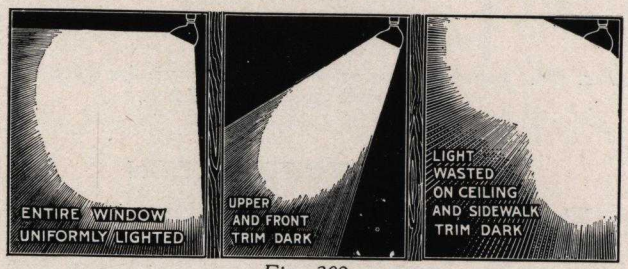


Fig. 309

USE OF PROPER LAMPS

To illustrate the importance of using the correct lamp for which the reflector was designed, the above diagram is presented.

This little diagram shows what happened when a 100-watt Mazda "C" lamp was installed in a No. 777 X-Ray Scoop reflector which was designed for 60-watt Mazda "B" lamp only. Even a change of shade holders to the Form "H" bringing the reflector down over the lamp does not materially help the condition.

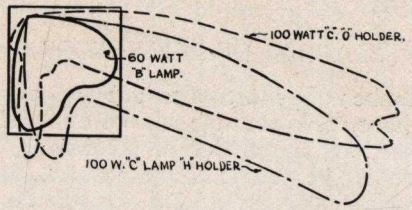
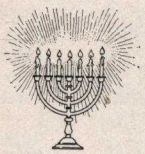


Fig. 310. Diagram showing the use of correct and incorrect lamps in the "Scoop" reflector.



XII PLANNING SHOW WINDOW LIGHTING

LIGHTING DETAILS FOR VARIOUS TYPES OF WINDOWS

Fig. 311. Typical display for shoe store. Note the effective lighting with units entirely concealed from view. Watkin's Inc., Minneapolis, Minn.

THE TYPICAL SHOW WINDOW

IT is safe to say that the success or failure of a show window lighting installation depends very largely upon the wise choice and proper use of lamps and reflectors. Each window presents a distinct problem for the merchant, architect and the lighting man. To illustrate the importance of using the correct shade of reflector of the most efficient type, it has often been found that by replacing old equipment with properly designed reflectors, the light on the goods can easily be doubled without any increase in current. In other words, it is common to find losses from 30% to 50% in window lighting installations. These losses are mainly due to the inefficiency of the reflectors used; to poor design or improper shape of reflectors, or to the use of reflectors which are neither intended nor suitable for window lighting.

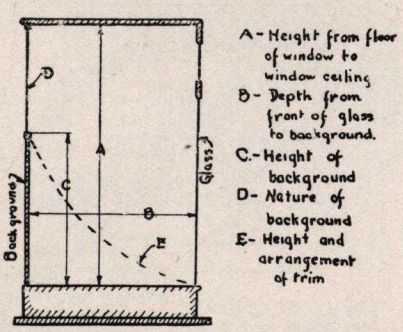


Fig. 312. Cross section of typical show window. Letters indicate dimensions and conditions that influence the selection of lighting equipment.

The lamp and reflector are the essential elements of the lighting unit. Now, that window lighting methods have been fairly standardized, the lamps most commonly used are the 75-watt and the 100-watt Mazda "C".

The chief factors to be considered in the selection of lighting equipment are given in Figure 312. The height of the window, its depth, the height and nature of the background and trim. On a previous page, windows were roughly divided into three general classes—high, average and low, each of which may be either deep or shallow. High narrow windows which require a concentrated beam of light are the most difficult to illuminate satisfactorily. The majority of the average windows can be best lighted with a "Scoop" shape reflector shown on page 165. This kind of reflector lights the high points of the trim and also gets light down on the lower portions of the display.

Methods of trimming show windows vary, and in many cases of high trim it is necessary to use two distinctly different types of reflectors to get an evenly illuminated display. One type lights the upper trim and another type will concentrate light down on the middle and bottom trim.

It is only of recent years that the proper consideration has been given to the nature of the background in the selecting of window lighting equipment. Backgrounds may be solid, mirrored, open, or made partially or entirely of glass. Especially in the case of an open or glass background is it necessary to use care in selecting a type of reflector

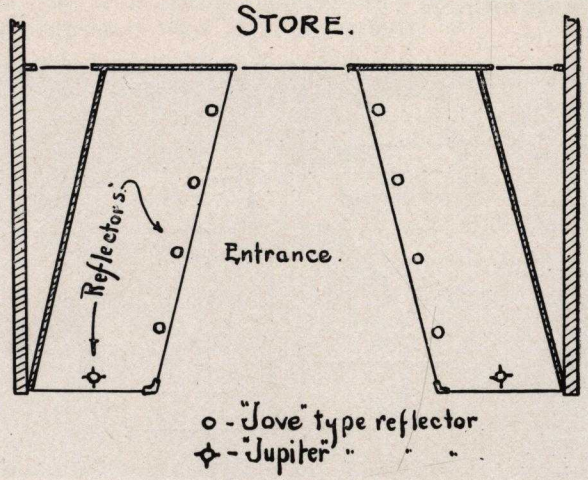


Fig. 313. Plan of show window which is illustrated above Correct location of lights is indicated.

which comes down over the lamp far enough to prevent the direct light of the lamp from going into the store. Customers and clerks need not be subjected to the annoying and harmful glare of the brilliant lamp filament when reflector units can now be obtained to take care of this condition.

Fig. 314. The "Jove" reflector designed especially for show window lighting with 100 watt Mazda "C" lamp, suited to windows of average proportions.

A typical example shown in Figures 311 and 313 indicate that effective window lighting with the proper reflectors can be accomplished at a moderate cost for current. Only 5 100-watt lamps are used in each window, with the units spaced about 30 inches apart. The Jupiter type of concentrating reflector which is placed on the street side of these windows has been installed to brilliantly illuminate the front and cause it to stand out attractively from a distance.

The mechanical features of an installation should not be overlooked in placing reflectors. Much trouble will be avoided if standard wiring and fittings are employed. Recommended shade holders should be used, and the suggestions of the electrical contractor followed regarding proper sockets and wiring methods.

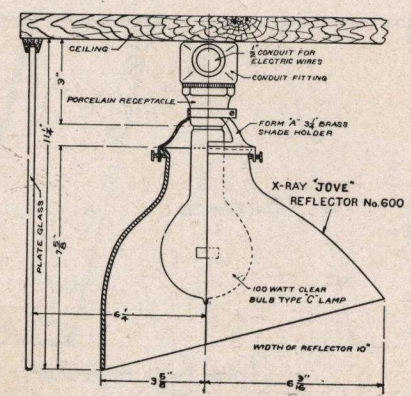


Fig. 315. Proper method of installing show window reflectors at ceiling and near plate glass. Lamps hang in natural pendant position. Standard wiring fittings are used.

THE ARCADE WINDOW

The arcade window is the show window in the most highly developed form and symbolizes the confidence of the modern merchants in the pulling power and business getting effect of attractive displays. It produces a brilliant and showy front for the store as well as a spacious area for the display of merchandise.

Fig. 316. Arcade and show windows properly lighted. The windows of the L. Strauss & Company Store, Indianapolis, Ind.

The arcade window is especially suitable for stores with narrow fronts, where a generous window area is desired at the greatest economy for space. This type of window might be said to take two general forms, the first of which is illustrated in Figure 318, having an island window and with the arcade running parallel with the street. The second form which is shown in Figure 320 is without an island window and with the arcade running perpendicular with the street. The first form with the island window is usually found where the store has a comparatively wide front, whereas, the second form is more suitable to stores with narrow fronts.

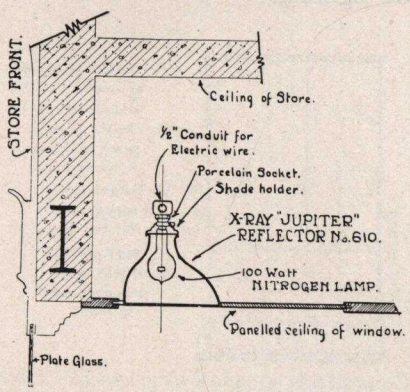


Fig. 317. Manner of installing "Jupiter" reflectors flush with window ceiling.

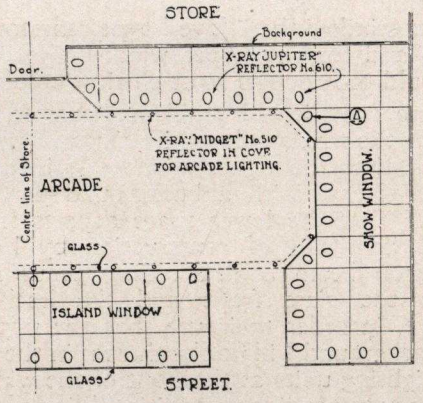


Fig. 318. Half plan of store front of L. Strauss & Company.

The conditions which exist in this type of window are very different from those to be found in other classes of show windows. The arcade window is, therefore, probably the most difficult type of show window to properly illuminate and in planning the lighting which must be done very carefully the following points must be considered.

(1) Conceal the lamp as much as possible from the eyes of the observer.

(2) Provide proper means of lighting the goods with units so arranged that the far corners of the window will receive ample illumination of uniform intensity.

(3) Provide a suitable and pleasing system of lighting for the arcade space.

The illustration in Figure 316 shows an arcade window where the above points have been worked out in an interesting manner.

For the lighting of the show windows themselves a specially designed "Jupiter" X-Ray reflector has been employed. This reflector cuts off sharply at the glass front without sacrificing the high intensity which is so essential to the proper lighting of the display. By referring to Figure 317, it will be noted that the "Jupiter" reflectors are so installed that they do not protrude below the ceiling of the window into the window space, but are set flush in the panels of the wooden ceiling.

This method cannot always be employed, due to

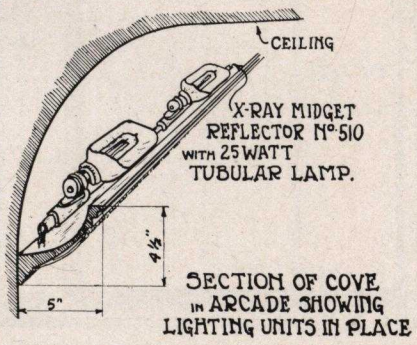


Fig. 319. Perspective section of cove showing reflectors.

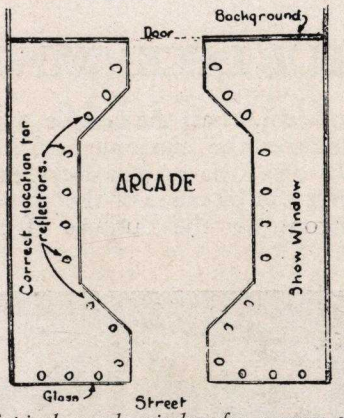


Fig. 320. Typical arcade window for narrow store fronts.

the fact that the ceiling of the window many times coincides with the ceiling of the store. However, where the construction of the window provides a space above the window ceiling, the method illustrated in Figure 317 can be easily worked out.

The proper location for the reflector units is clearly indicated in the half plan shown in Figure 318. The reflector at "A" is installed in such a manner that its light will be directed to the far corner of the window to build up the intensity of light at that point and make it equal and uniform with the illumination which is received in other portions of the window.

It will be noted that the island window which has glass on all four sides has a double row of units, one on the street side and one on the side facing the arcade.

Special attention is called to the method of illumination employed for the arcade, an excellent example of the modern method of lighting from concealed sources. A series of reflectors extending around the sides of the space in an ornamental cove throws the light to the ceiling where it is reflected into the arcade producing the beautiful and pleasing result of indirect lighting. This method does away entirely with glaring hanging units and insures an unobstructed view in all directions.

Fig. 321. View from the street of the arcade window of L. Strauss & Company.

DOUBLE DECK WINDOWS

The same way that the arcade type of show window indicates the maximum efficiency utilization of floor area, the double deck windows show how the most can be made of the vertical space of the store front for the purpose of merchandise display.

Fig. 322. An excellent example of "double deck" show windows. The Hub, Chicago, Ill.

This type of window, while not very generally used, has a very useful application in special instances. Stores which are located on street car and elevated car lines or on thoroughfares which have a large amount of vehicle traffic can make effective use of the double decked window. In Figure 322 is illustrated a show window of the Hub Store in Chicago, located on the boulevard which carries the majority of the cross town traffic of the metropolis.

The drawing in Figure 323 shows the cross section of the show window and clearly indicates the proper position of the reflector equipment.

Under ordinary circumstances in working out the illumination of the double decked window, it should be considered as two distinct windows, and the lighting arrangements for each should be determined independently; thus the problem is simplified. Take, for instance, the window in Figure 325. In this case the upper and lower windows are of the box type, constructed with solid background. The lower window was one of average proportions while the upper window, although having the same depth as the lower one is of such a height as to make it practically square in section. By applying the general principles which had been discussed on other pages, we find that for the proper lighting of the lower window the "Jove" type reflector should be used and for the upper window the "Scoop" type would provide the most efficient results.

A more complicated problem, however, is presented in the window shown in Figure 323. It will be noted that the upper window is in reality a small show case with a background partially of glass and that the lower space departs from the ordinary box type of construction by having a heavy drop beam at the ceiling about midway between the glass front and the background. Therefore, in order to insure that the upper part of the background will not be thrown in the shadow by the lighting units at the front of the window, it is necessary to provide an additional line of lighting units at point "B." The light from these units is directed at the upper portion of the background and the reflector units are so adjusted that the lighting from both sets of reflectors overlaps and mixes in such a manner as to give a uniform result from the floor to the ceiling of the window. At the

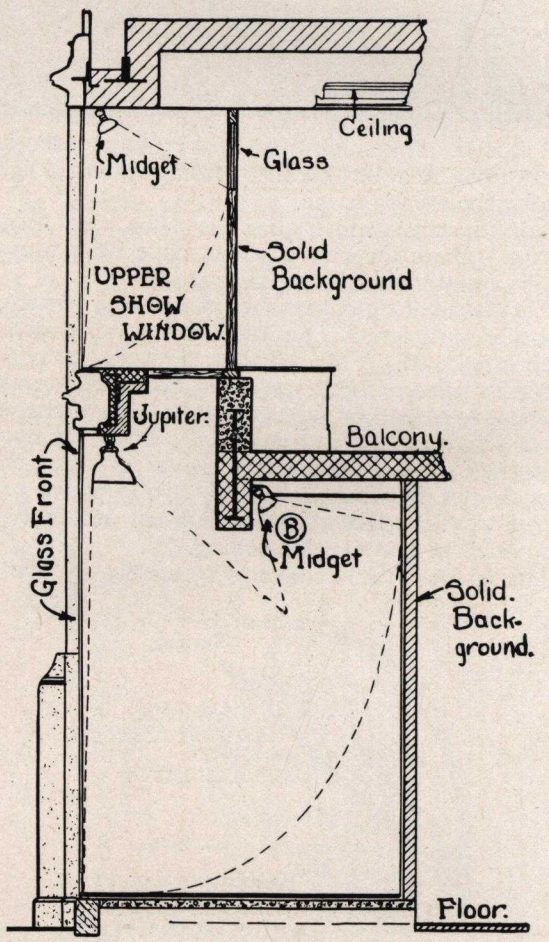


Fig. 323. Cross section of the windows of The Hub Store.

Fig. 324. "Double deck" window, type shown in the figure below. Armstrong Clothing Co., Minneapolis, Minn.

point "B" and for the lighting of the upper deck window X-Ray Midget Reflector No. 515 is used, with 25-watt tubular lamp burning in a horizontal position. The Midget is selected in this case because it has the proper distribution of light for the conditions to be found and also because this type of reflector can be installed in the minimum of space.

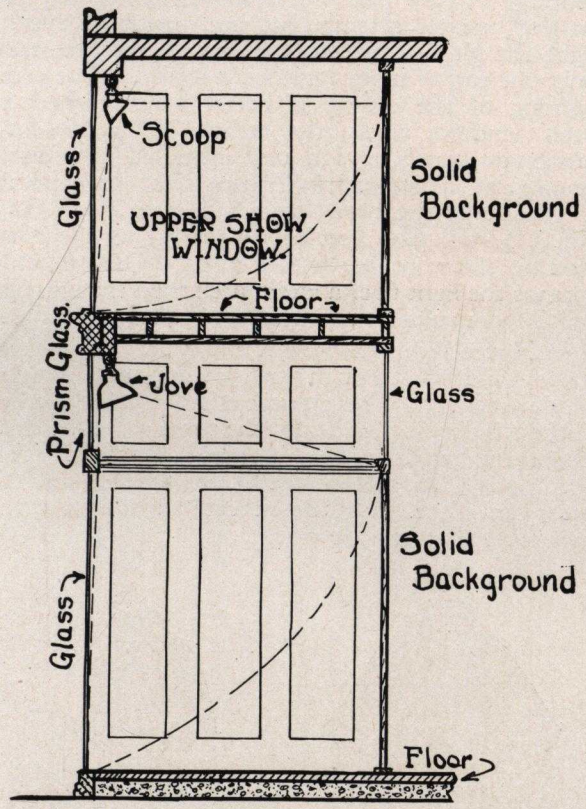


Fig. 325. Typical form of "double deck" show window.

SHOW WINDOWS WITH GLASS CEILING

We frequently see show windows which have glass ceilings through which at night the illumination is received. This scheme of lighting is especially suitable for show windows in which a great variety of small objects of many sizes are shown—such as jewelry, shoe displays, florists displays, etc. It has its largest application in small shallow windows in which jewelry and optical goods are shown.

The particular advantage of lighting a show window by means of units which are placed above the glass ceiling is that the window may be made practically dustproof and airtight. This is especially desirable in windows such as illustrated in Figure 326 where optical goods are displayed. After the display is once arranged, it is a difficult matter to keep polished surfaces of the various articles free from an accumulation of dust and dirt unless the entire display window is made dustproof. By installing reflectors above the glass ceiling a large percentage of the heat which is generated by the lighting unit is kept out of the case or display window, making it possible to design the window practically airtight without fear of damaging the goods displayed because of the excessive heat which might be confined in the window in case the lighting units were also included within it.

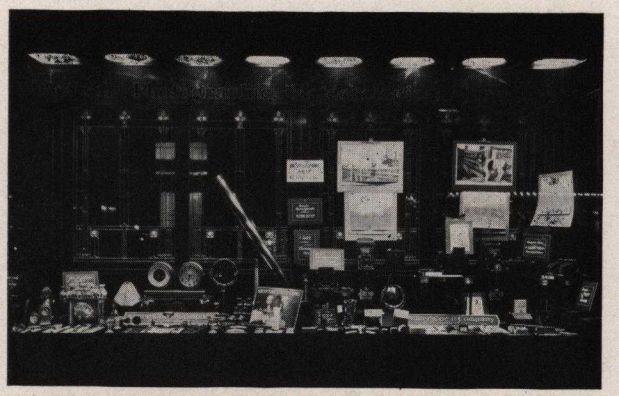


Fig. 326. A shallow window with glass ceiling. Almer Coe & Company, Chicago, Ill.

The high and brilliant intensities of light cannot be expected with this system that are obtained where the reflectors are installed as described in previous pages—that is, where the light is reflected directly on the goods without passing through the glass.

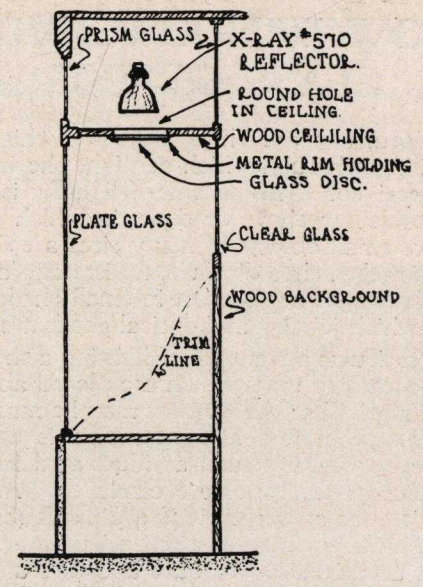


Fig. 327. A method of lighting from the ceiling of the show window.

The choice of the proper glass for the ceiling is an important item. The glass should be of such a nature that it transmits a maximum proportion of the light and at the same time prevents a view of the equipment which is placed above the ceiling. Ordinary ground glass is sometimes used, but it absorbs a great deal of light. Other forms of decorative clear glass are more desirable.

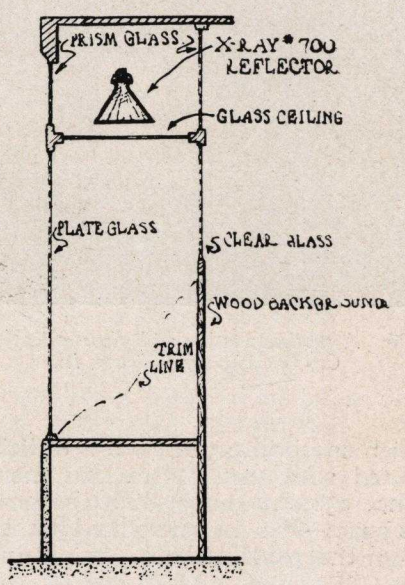


Fig. 328. Section of show window shown in Fig. 326.

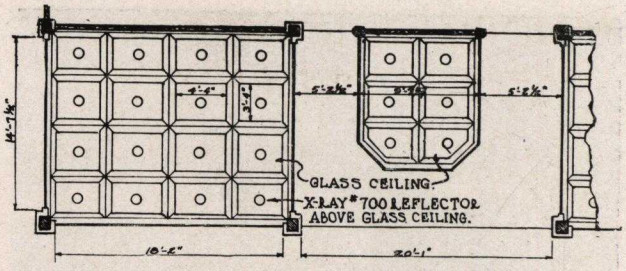


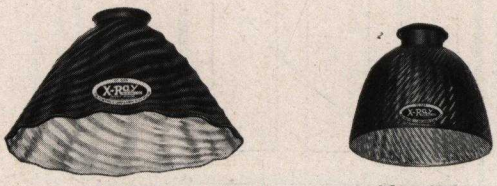
Fig. 329. Plan of the deep window with panelled ceiling showing numerous lights placed over glass.

Care should be exercised in the selection and placing of the lighting equipment, as the general appearance of the ceiling when the lights are turned on has much to do with the pleasing effect obtained with a system of this kind.

Because of the loss of light which occurs by the passing of the rays of light through the glass ceiling, the most efficient reflectors obtainable should be used.

In Figure 326 is illustrated a very shallow window with a concentrating type of reflector placed close to the glass ceiling. A cross sectional view of this window is given in Figure 328, and the type of reflector X-Ray No. 696 is shown in Figure 330. In this case no attempt has been made to evenly light the glass of the ceiling, due to the fact that only one row of units could be installed. The even lighting of the ceiling is better accomplished in deep windows where the ceiling is divided into numerous panels and a unit installed over each square, as illustrated in Figure 329. In general, a reflector of the type shown in Figure 330, X-Ray No. 535, will give best results as far as the even lighting of the ceiling is concerned. This reflector spreads the light over a larger area than the No. 696 and is more suitable to windows of the shallow type.

In Figure 327 is shown a method for lighting the show windows through an opening cut in the window ceiling. The general effect of the lighting of the window is practically the same as in the case where the entire ceiling is made of glass. The opening is fitted with a metal rim which supports the glass plate, and the reflector installed comparatively close to the disc.



No. 696. *No. 535.*

Fig. 330. Reflectors for lighting from above show window ceilings.

INDIRECT LIGHTING IN SHOW WINDOWS

The solution of the lighting problem for this window illustrated in Figure 331, was difficult inasmuch as it was desired to entirely conceal the lighting equipment from view. An indirect lighting scheme was therefore adopted. The reflectors are placed in an ornamental cornice or cove about 12 feet from the floor of the window. The light from these reflectors is directed to the barrel shaped ceiling and is again reflected into the window space.

The island window in this case is unusually large being 11½ feet deep and 46 feet long. It is used to display only a very few of the most exclusive gowns. The reflector equipment employed consists of 40 X-Ray reflectors with 40 and 60-watt lamps and placed 7½ inches on centers.

Fig. 333. Indirect lighting in this show window accomplished by means of fixtures pendant from the ceiling. King's Shop, Toledo, Ohio.

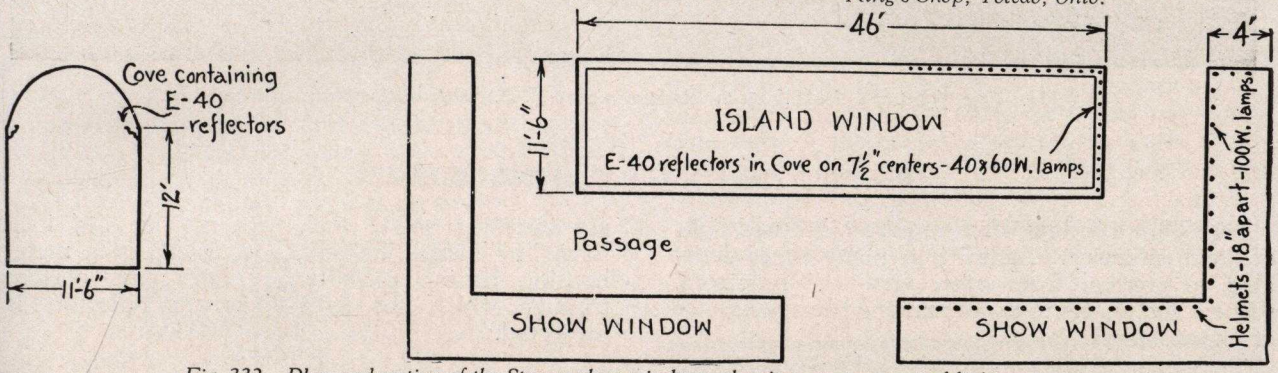


Fig. 332. Plan and section of the Stevens show windows, showing arrangement of lighting units.

Fig. 331. The island window of Charles A. Stevens & Brothers Store, Chicago. Photographed at night from the rear, showing indirect illumination.

Window lighting problems of this character are difficult to work out successfully, and should be adopted only in co-operation with experienced illuminating engineers.

The hanging bowl fixtures which are shown in Figure 333, each contain silvered X-Ray reflectors, especially designed for indirect lighting. The indirect method does not produce brilliant show window lighting but gives a peculiar quality which is very suitable to certain kinds of display.

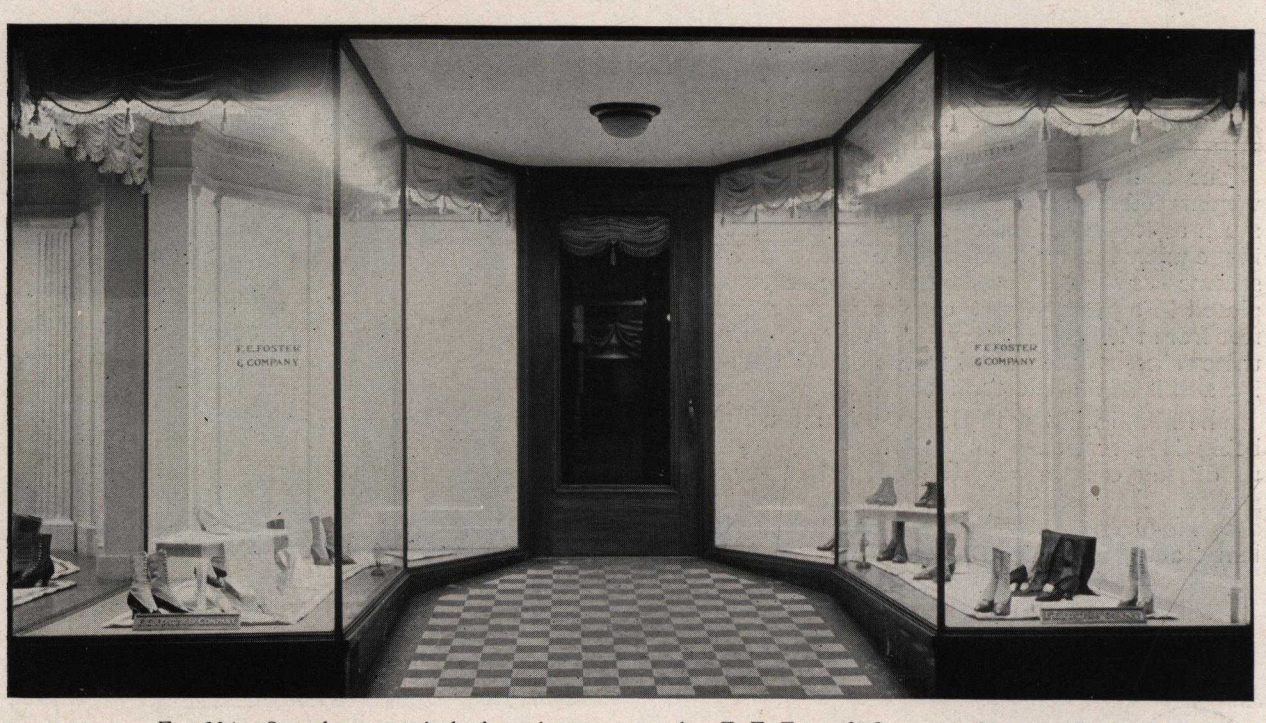


Fig. 334. Store front as it looks from the street at night—F. E. Foster & Company, Chicago, Ill.

DIFFUSED LIGHTING FOR SHOW WINDOW

High-class displays often require a diffused light of great intensity. Again, it is many times desirable to conceal from open view the reflectors, sockets and wiring to avoid marring the appearance of the windows.

The show windows of the F. E. Foster Shoe Company here illustrated were equipped to accomplish both of the above requirements. The window

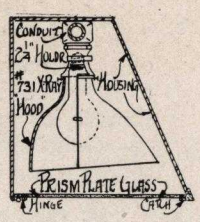


Fig. 335. Cross section of the housing containing X-Ray reflectors.

is of the vestibule type 7 feet 6 inches high. A minimum of space was allotted for the placing of the lighting equipment. The Hood No. 731 was therefore selected, not only because its depth is 7 inches, but also because it is the type of reflector whose distribution of light is especially suited to this window. The reflectors with 75 watt lamps are installed on 12 inch centers with 2¼ inch form "H" shade holders, and placed in a metal housing having a diffusing plate glass bottom through which the light from the reflectors is projected.

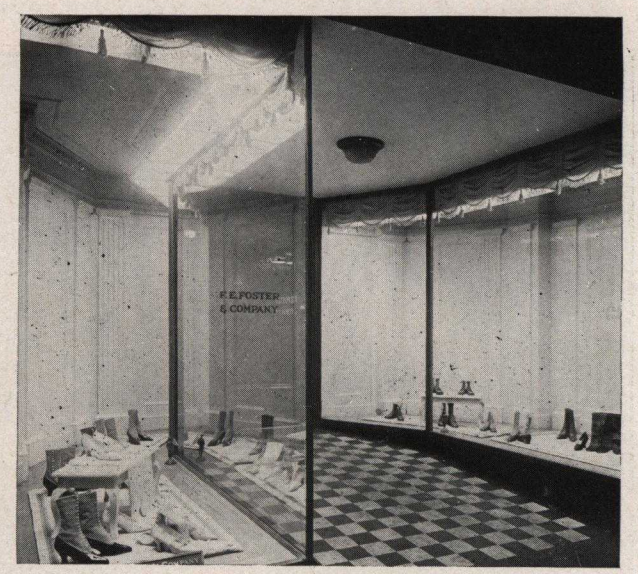


Fig. 336. View showing location of special lighting equipment.

SHOW WINDOW VALANCE

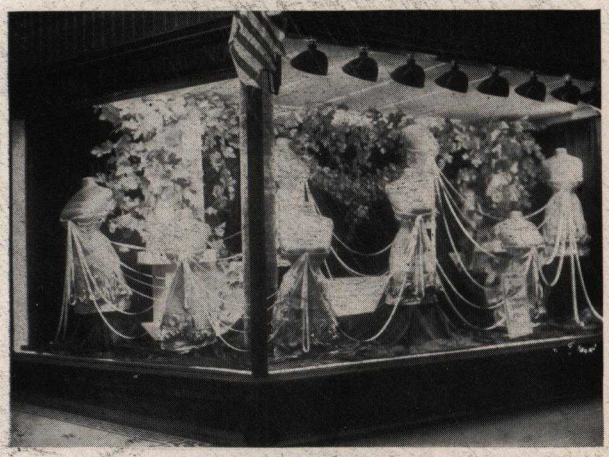


Fig. 337. Exposed reflectors are objectionable. The appearance of the window could be improved by using the valance.

The valance or window drape serves two purposes.

First, it provides an excellent means of concealing reflectors that have been installed for the lighting of the display. Second, it has a decorative value.

The valance is rapidly replacing the painted band which has been used for many years to overcome the objection of exposed reflectors. It is much more distinctive and infinitely more attractive.

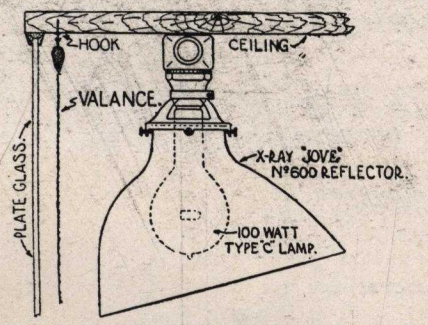


Fig. 338. Diagram showing the correct location of valance to conceal show window reflectors.

This point is clearly illustrated by referring to Figures 337 and 339. In Figure 337, the right half of the picture shows the reflectors exposed to full view.

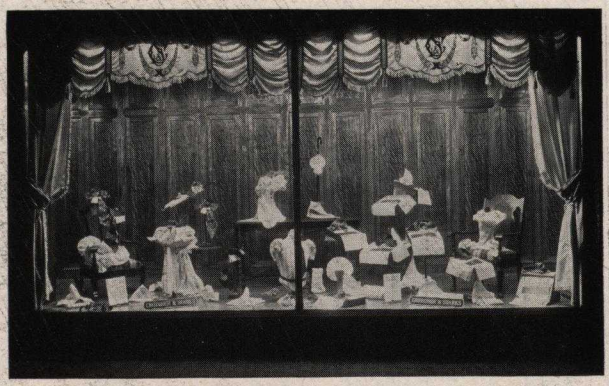


Fig. 339. Compare this to the illustration at left. Note the effectiveness of the valance.

The reflectors are properly installed at the ceiling of the window near the glass plate front. They are conspicuous to the extent of detracting from the effect of a pleasing display in the window. At the left in Figure 337, the reflectors are entirely out of sight back of the band painted on the glass. Contrasting this with Figure 339, the effectiveness of the valance is at once apparent.

The proper method of hanging the valance in the show window is illustrated in Figure 338.

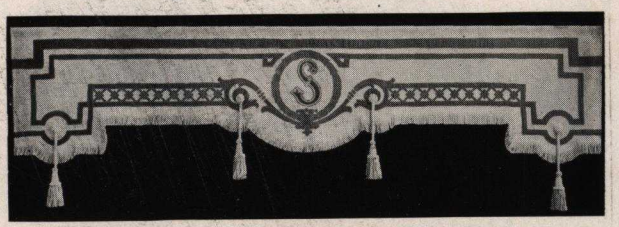
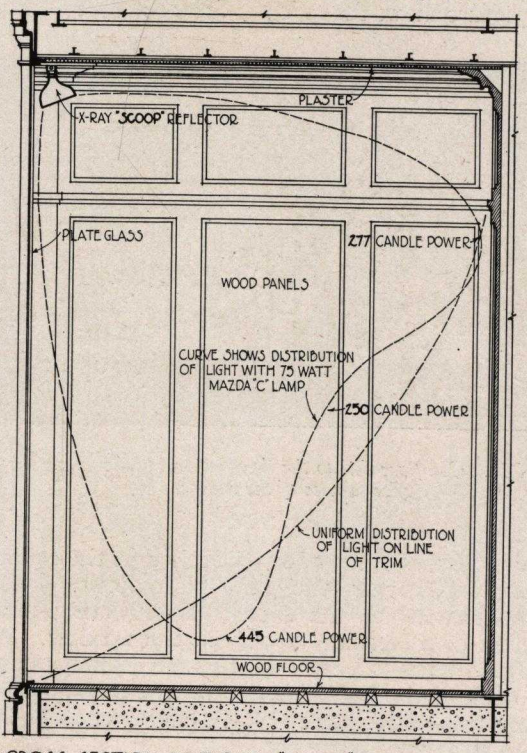
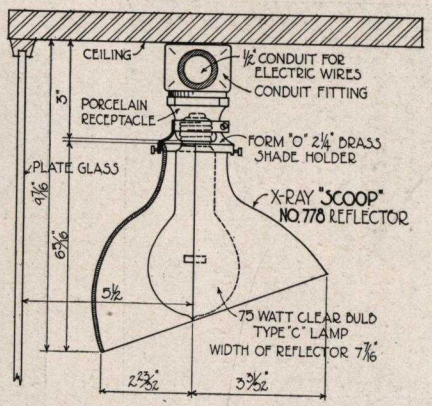


Fig. 340. Typical valance design.

SPECIALLY DESIGNED REFLECTORS [WITH HIGH TEMPERATURE DACKING] FOR GAS FILLED MAZDA "C" LAMPS



CROSS SECTION OF TYPICAL "SCOOP" SHOW WINDOW

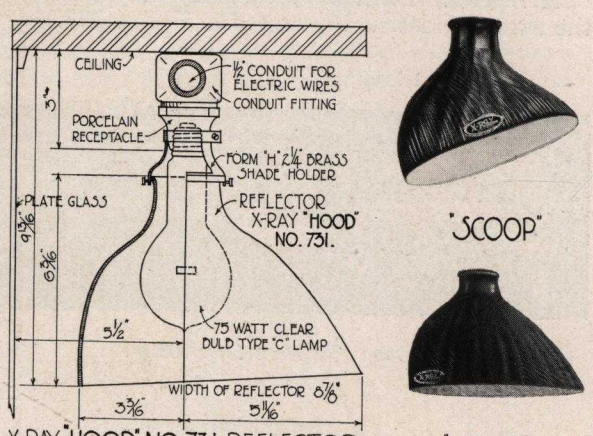


X-RAY "SCOOP" NO. 778 REFLECTOR

THE X-RAY "SCOOP" IS INTENDED TO ILLUMINATE SHOW WINDOWS WHOSE DEPTH IS ABOUT EQUAL TO THE HEIGHT, AND WHERE THE TRIM IS HIGH IN THE BACKGROUND OF THE WINDOW. PREFERABLY FOR WINDOWS WITH SOLID BACKGROUND. THE RECOMMENDED SPACING OR DISTANCE FROM CENTER TO CENTER OF REFLECTORS IS AS FOLLOWS:

FOR AVERAGE ILLUMINATION - 24 INCHES.
FOR BRIGHT ILLUMINATION - 18 INCHES.
FOR VERY BRIGHT ILLUMINATION - 12 INCHES.

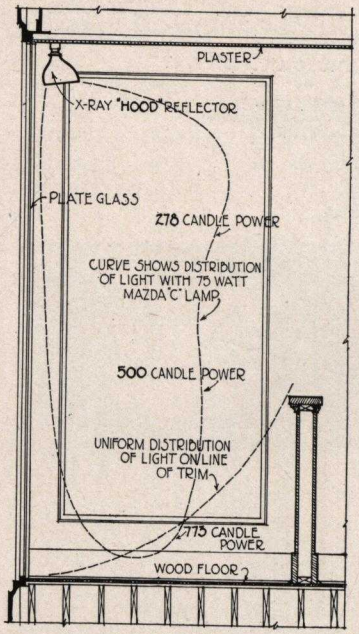
THE X-RAY "HOOD" REFLECTOR IS A "LIGHT CONCENTRATOR" IDEAL FOR SHALLOW WINDOWS; THOSE WHOSE DEPTH IS ABOUT ONE-HALF OF THE HEIGHT, ALSO FOR WINDOWS WITH GLASS OR OPEN BACKGROUND, OR WITHOUT BACKGROUND. THE RECOMMENDED SPACING IS THE SAME AS GIVEN ABOVE FOR THE "SCOOP."



X-RAY "HOOD" NO. 731 REFLECTOR

"SCOOP"

"HOOD"



CROSS SECTION OF TYPICAL "HOOD" SHOW WINDOW

GENERAL NOTES

THE X-RAY "SCOOP" AND "HOOD" REFLECTORS WERE BOTH DESIGNED FOR USE WITH THE 75 WATT GAS FILLED MAZDA "C" LAMP. LIKE ALL X-RAY REFLECTORS THEY ARE MADE OF ONE PIECE GLASS PURE SILVER PLATED AND CORRUGATED TO BREAK UP THE LIGHT RAYS, THUS PREVENTING ALL STREAKS AND UNEVENNESS IN THE LIGHT. USE THE "SCOOP" AND "HOOD" FOR WINDOWS UP TO ABOUT 9 FEET IN HEIGHT. FOR HIGHER WINDOWS THE "JOVE" AND "JUPITER" SHOWN ON PLATE NO. 37 SHOULD BE EMPLOYED.

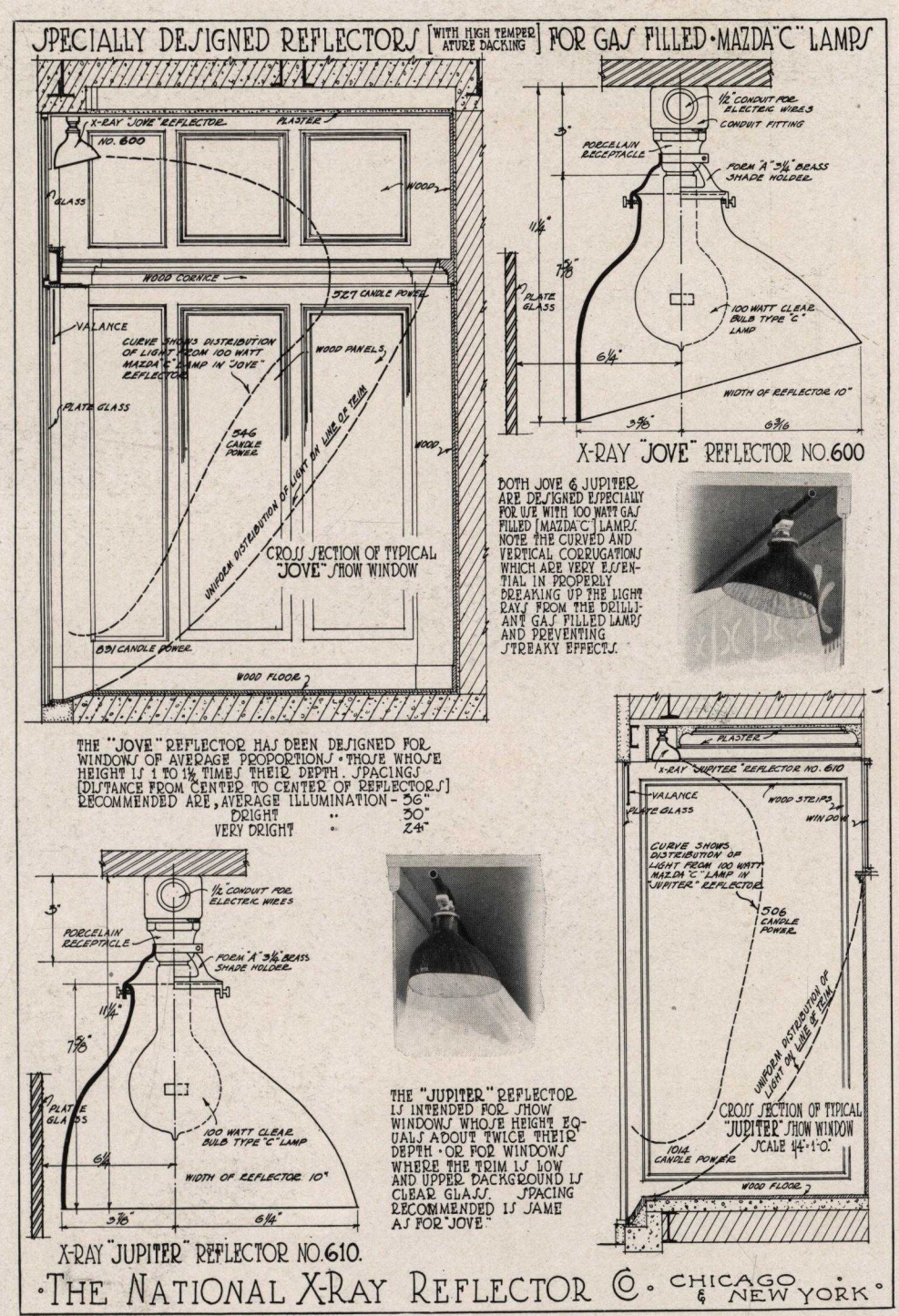
SHOW WINDOWS

THE USES OF THE SCOOP AND HOOD ARE MORE FULLY DESCRIBED ON PAGES 164 TO 167.

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

SHOW WINDOWS

THE PRACTICAL APPLICATIONS OF X-RAY WINDOW LIGHTING ARE BEST SHOWN BY THE EXAMPLES GIVEN ON PAGES 169 TO 176.



A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

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XIII SHOW CASE AND WALL CASE LIGHTING

WITH THE SCOOPETTE AND HOODETTE

Fig. 341. Cases lighted only by Scoopette and Hoodette, Minneapolis General Electric Co., Minneapolis, Minn.

THE SCOOPETTE

THE show case as used today is in reality a miniature show window, rather than a case for the storing of merchandise. Hence, its illumination should receive as careful consideration as the show window lighting. The lighting requirements are very nearly the same except that in the show case lighting, it is not only necessary to conceal the lamp from the view of the customer, but it is essential to shield the eyes of the clerk from the glare of the lamp as well.

From the practical standpoint, show case lighting equipment must be very small and unobtrusive, so that it will offer the least possible obstruction to the clear view of the contents of the case. The heat generated from the lamps must be as low as possible, and equipment must be properly constructed and installed so as to eliminate all fire hazards.

X-Ray Scoopette reflector and fittings were designed with the above lighting requirements and practical considerations as a basis.

Fig. 342. The X-Ray Scoopette unit No. S100 for show cases.

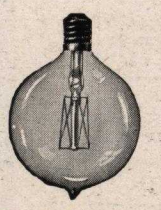


Fig. 343. A small 15-watt lamp used with the Scoopette.

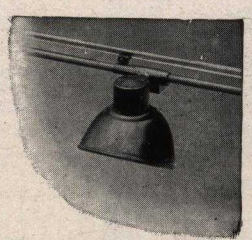


Fig. 344. The Scoopette as it appears installed in the show case.

ADVANTAGES OF THE "SCOOPETTE"

1. The reflector confines all the light to the case and evenly distributes it over the trim. Its shape is such as to completely conceal the lamp from both the view of the customer and clerk.
2. The reflector is designed to snugly fit around the smallest type and size of 15 watt 110 volt multiple tungsten lamp, and hence offers the minimum obstruction to view. Small metal tubing in which the feed wires are carried, offers practically no obstruction whatsoever.
3. The high efficiency of the X-Ray Reflector makes possible the illumination of show-cases with practically one half the wattage commonly employed and thus the heat generated is a minimum.
4. The electrical feed wires are enclosed in metal tubing from the floor outlet to the lamp base, making a strictly fireproof installation.
5. Because of the fewer number and lower wattage lamps required, to adequately illuminate a show case with "Scoopettes," the electrical energy cost is a minimum.
6. For the same reason the cost of lamp renewals and the maintenance for the cleaning of reflectors, etc., are also a minimum.

Scoopettes Compared to Other Appliances for Show Case Lighting

The accompanying chart shows in percentages the superiority of the Scoopette over the nearest competing devices.

The tests represented by this chart were made in a show case of standard dimensions on three types of equipment.

1. Continuous trough, lined with mirror strip. This is the latest type of trough for show case lighting. It measures 1½ inches across the face, which represents the smallest possible dimension in which the tubular lamps used may be accommodated. The lamps are spaced on 18-inch centers.
2. Individual trough having an aluminized metal reflecting surface. This trough designed especially for use with the 12-inch tubular lamp. The reflectors were spaced on 18-inch centers.
3. *X-Ray Scoopette* reflector. These reflectors are designed especially for use with the 15 watt spherical candelabra base lamp. They were spaced on 18-inch centers.

All results were reduced to the same wattage basis, so that they are strictly comparable.

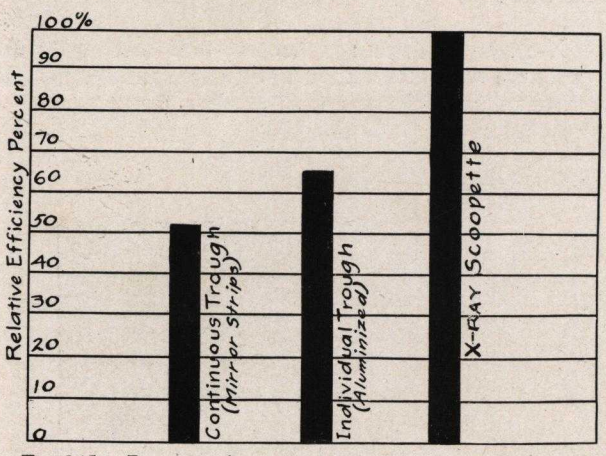


Fig. 345. Diagram showing relative efficiency of show case reflectors.

The chart shows that the individual aluminized trough reflector which is used with the 12-inch tubular lamp delivers only 65.6 per cent as much light onto the trim within the case as the X-Ray Scoopette Reflector. Likewise, the continuous trough lined with strips of mirror delivers only 51.7% as much light as the X-Ray Scoopette.

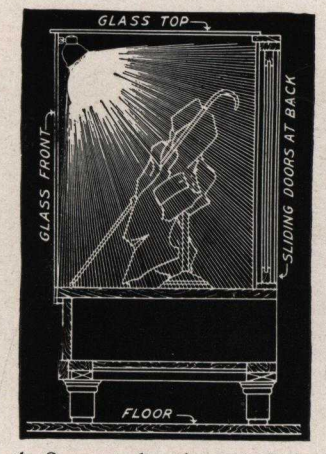


Fig. 346. How the Scoopette distributes the light in the show case

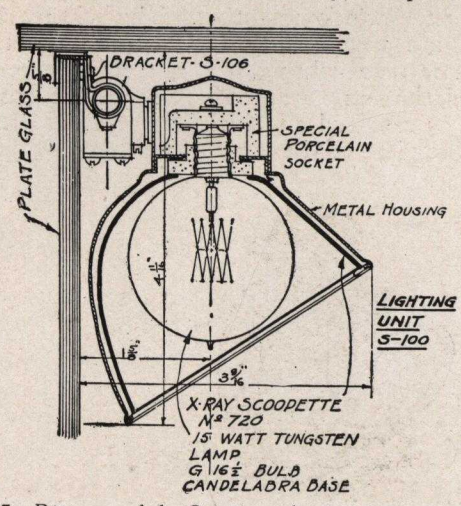


Fig. 347. Diagram of the Scoopette showing its correct position in the show case.

PLANNING SCOOPETTE LIGHTING FOR SHOW CASES

Scoopette outfits are complete with everything from the reflector to the fittings for attaching to the switchbox. The material includes special insulating joints, a push button switch, a special switch box, which is easily installed, all tubing, elbows, T-fittings, Scoopettes, straps or brackets for supporting the tubing, cap for end of tubing, and sufficient special flexible No. 18 stranded wire to wire the entire case. The assembling and wiring of the units on the job is a very simple matter.

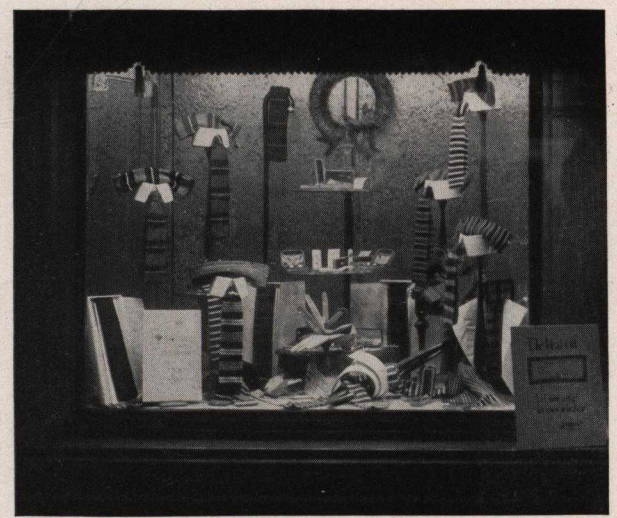
In general there are two kinds of show cases—the all plate glass cases and the cases having a wooden frame. The method of installing the Scoopette equipment is somewhat different for the two styles of cases, and will be described later.

NUMBER OF SCOOPETTES TO USE

The spacing of the Scoopette is determined by the intensity of the illumination desired in the show case, which in turn is dependent upon the type of goods to be displayed. In general, light goods require a lesser intensity than dark goods. On the other hand, with jewelry a high intensity is desirable in order to bring out the sparkle and luster of the jewels displayed. In all cases it must be remembered the object in illuminating the show case is to attract attention to the merchandise within. Therefore, we must provide sufficient intensity to obtain this aim.

As a guide to assist in the selection of the proper spacing of reflectors, the tables are given.

Table No. 5 gives the average illumination intensities which from experience are found to give the result desired. In Table No. 6 are given the spacing or distance apart of the units which will give the various intensities.



Display case in a show window lighted with X-Ray Scoopettes.

TABLE 5

Intensity of illumination for various displays.

Jewelry	15 to 20	foot candles
Drugs, rubber goods	15 to 17½	foot candles
Cut glass, silverware, china	15 to 17½	foot candles
Clothing, drygoods, furnishings	15 to 17½	foot candles
Shoes, hosiery, hats	15 to 17½	foot candles
Hardware, cutlery	15 to 17½	foot candles
Candies, groceries, fruits and bakery goods	10 to 15	foot candles

TABLE 6

Spacings and intensity of light.

14-inch spacer; 15-watt lamp;	20	foot candles;	very bright.
16-inch spacer; 15-watt lamp;	20	foot candles;	very bright.
18-inch spacer; 15-watt lamp;	17½	foot candles;	bright.
20-inch spacer; 15-watt lamp;	17½	foot candles;	bright.
22-inch spacer; 15-watt lamp;	15	foot candles;	bright.
24-inch spacer; 15-watt lamp;	15	foot candles;	bright.
26-inch spacer; 15-watt lamp;	12½	foot candles;	average.
28-inch spacer; 15-watt lamp;	12½	foot candles;	average.
30-inch spacer; 15-watt lamp;	10	foot candles;	average.
32-inch spacer; 15-watt lamp;	10	foot candles;	average.

NOTE—Spacing distance center to center between Scoopette equals the length of the spacer plus 1¼ inches.

TABLE 7

Catalogue numbers for complete show case lighting outfit.

Length of Case	Number of Scoopettes	Degree of Brightness	Overall Length	Catalogue Number
4′	2	Bright	45⅞″	S 46 G2
6′	2	Average	69⅞″	S 70 G2
6′	3	Bright	69⅞″	S 70 G3
6′	4	Very birght	68⅜″	S 70 G4
8′	3	Average	93⅜″	S 94 G3
8′	4	Bright	92⅜″	S 94 G4
8′	5	Very bright	93⅜″	S 94 G5
10′	4	Average	116⅜″	S118 G4
10′	5	Bright	117⅝″	S118 G5
10′	6	Bright	116⅞″	S118 G6
10′	7	Very bright	117⅝″	S118 G7
12′	5	Average	141⅝″	S142 G5
12′	6	Bright	150⅞″	S142 G6
12′	7	Bright	140⅛″	S142 G7
12′	8	Very bright	141⅜″	S142 G8

The above information applies to wooden frame or all glass show cases having square ends. Catalogue numbers are for back entrance method outfits.

Many cases both of the wooden frame and all glass type have round ends. In this case it is necessary to bend tubing to fit the curves of the case. The radius of the curve is usually within the limit of 7 to 31 inches.

HOW SCOOPETTES OUTFITS ARE INSTALLED IN SHOW CASES

Diagrams below illustrate the methods of installing the Scoopette, and indicate the way in which the various fittings are employed.

One method shows the wires entering the case through the floor, and the other method shows the feed wire coming up the back corner post of the case from the switch box.

The method employed depends upon the construction of the case.

If the show case does not conform with the standard sizes given in the tables, send for a special dimension blank, so as to give us the exact information. This is very necessary so as to insure that the equipment exactly fits the case.

No cutting or threading will be necessary if we furnish this equipment for any show case of which we have these simple dimensions. See Fig. 349.

(A) Inside length of case, glass to glass.

(B) Measurements across end of case inside of front glass to outside of back corner post.

(C) Measurement from underside of top glass to underside of floor of case.

In addition, state whether case is all glass or wooden frame.

Fig. 349

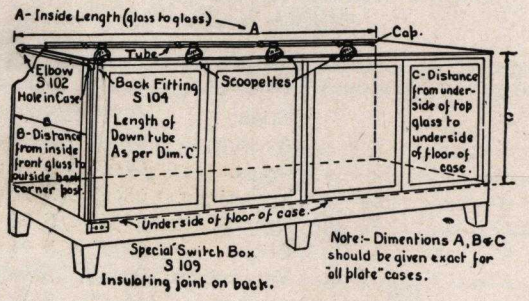


Fig. 348. Diagram showing the back entrance method for all plate cases.

BACK ENTRANCE METHODS FOR ALL PLATE CASES

The feed wires are brought up behind one of the back posts, the tubing extends across the case from one end just under the top glass, and is connected with the front tube by an elbow. With this method it is not necessary to disturb the trim, move the case, or tip it over.

FLOOR ENTRANCE METHODS FOR WOODEN FRAME CASES

The feed wires enter from underneath the floor of the case, extending up to the flexible conduit which is concealed back of one of the front corner posts.

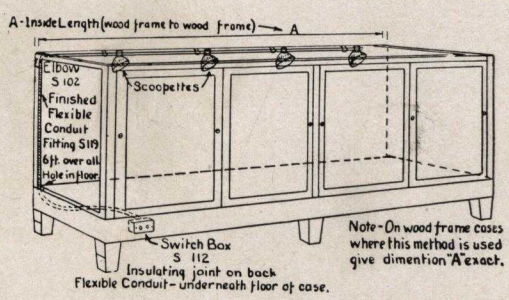


Fig. 350. Diagram showing the floor entrance method for wood frame cases.

FITTINGS FOR SCOOPETTES OUTFITS

Below are illustrated the various fittings used with the Scoopette in making up the complete show case lighting outfit. The fittings are designed to occupy minimum of space; all fittings are finished in black nickel; all of the fittings are National Electrical Code Standard.

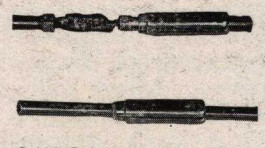
These fittings can also be used with the Hoodette reflector, which is described on the succeeding pages.

Assembled Scoopette Equipment

Small Approved Scoopette and Hoodette Fittings

No. S-131 Reflector clip and casing, with holder for standard brass shell socket.

No. S-132 Hoodette holder for standard brass shell socket.



No. S-129 Coupling for ⅜-inch tube.

No. S-101 Body or T-fitting with cover.

No. S-102 Elbow with cover.

No. S-108 Connector.

No. S-104 Back fitting with cover.

No. S-103 Offset fitting.

No. 109 Special switch box with black enamel cover

No. S-106 Bracket for all glass cases.

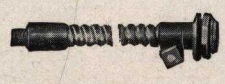
No. S-136 Bracket. for wood frame cases

No. S-121 Fitting for flexible conduit.

No. S-120 Fitting for attaching flexible conduit to S-101 body.

No. S-105 Cap and tubing.

No. S-114 Special insulating joint, including nipple and lock-nuts.



No. S-119 Special flexible conduit, with fittings, 72 inches long, 36 inches showing in case finished black nickel.

THE HOODETTE FOR WALL CASE LIGHTING

Fig. 351. Contrast the cases at right and left of this picture—note the difference in attractiveness.

The same care should be exercised in lighting displays inside of the store as is used in the show windows. Many wall cases are not lighted, and, therefore, lose much of their attractiveness. This point is clearly illustrated in Figure 351, which shows a case at the right lighted with X-Ray Hoodette units.

In contrast with this is a case at the left which does not have individual lighting but depends upon the general illumination of the store to brighten up the goods displayed. It is at once evident that the display at the right will attract more attention and more goods will be sold from this case than from the case at the left.

Fig. 352. X-Ray Hoodette unit, No. S99 for wall case lighting.

The Special Hoodette equipment for wall case lighting is much more economical than the old form of tubular lamp which has been in use for many years. This equipment shown in Figure 352, like all other X-Ray lighting systems, has an individual reflector for each lamp, and from which it is possible to get better control of light.

Wall cases are ordinarily difficult to properly illuminate; the trim is almost vertical in position and extends from top to bottom of the case. A concentrating type of reflector is required for the most economical lighting. For the floor cases, the more spreading or distributing unit is desired, and for this requirement the "Scoopette" has been designed.

Dimensions of the Hoodette

The Hoodette reflector unit is designed to illuminate the average wall case, which is about 72 inches high and 30 inches deep, inside dimensions. The dimensions of cases vary considerably from the above, but yet the Hoodette is designed to take care of a fairly wide range of requirements.

The Hoodette Unit No. S-99 includes the reflector socket, socket cover and shade holder, as illustrated.

Height including sockets 4⅛ inches; depth front to back 5⅜ inches; width of reflector 3 11-16 inches; lamp 15-watt, G. 16½, candelabra base, holder special supplied with the reflector.

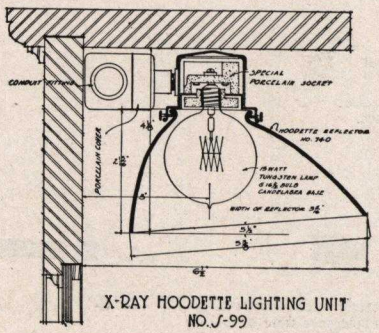


Fig. 353. Correct location for the Hoodette unit.

MANNER OF INSTALLING THE HOODETTE

The wires are brought up back of the case and enter an outlet box at the top. The switch for controlling the lamps is concealed at one end of the case. The lamp circuits in two or more cases can be connected as shown in the diagram below. This diagram shows an arrangement in which ordinary conduit and conduit fittings are employed. If it is necessary to economize in space in order to conceal the Hoodette unit, Scoopette fittings shown on page 185 can also be used for the installing of the Hoodette.

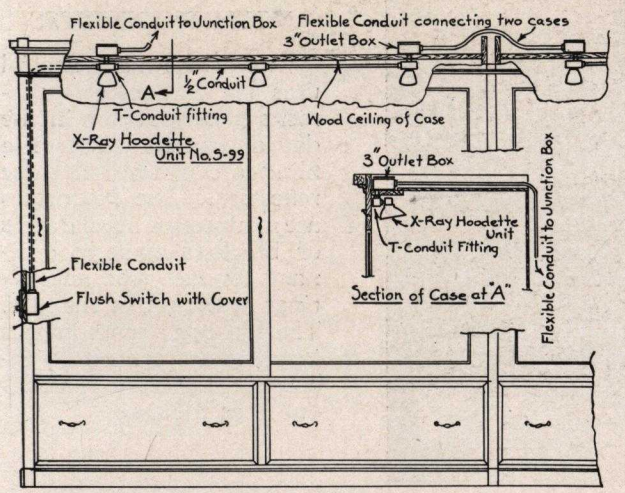


Fig. 354. Correct method of installing Hoodettes in a typical wall case.

The proper location for the "Hoodette" is shown in Figure 354. The lamp is entirely concealed and at the same time gives brilliant illumination throughout the case. Wall case lighting with this equipment is economical. For the wall case shown in Figure 351, which is in a prominent Chicago jewelry store, the cost of lighting is only about 1 cent per hour.

Wall cases are usually made with a framing or cornice at the top behind which the lighting equipment may be concealed. Therefore, the reflector need not be quite so small as the Scoopette, but, nevertheless must be easily concealed.

The socket which is the same type as used with the Scoopette takes a small 15-watt lamp.

The Hoodette may be used with the standard Scoopette show case fittings or regular conduit fittings as desired. In many cases considerable saving in intial cost of installation may be made where the head room permits the use of standard conduit and fittings.

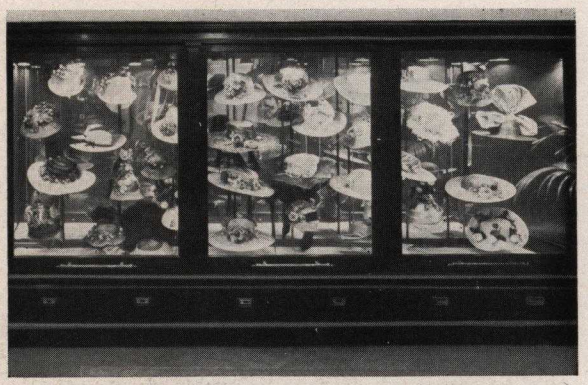


Fig. 355. Wall display case lighted with Hoodettes.

MILLINERY CASE LIGHTED WITH HOODETTE

The above view of the millinery case lighted with Hoodette shows one of the many uses of this efficient lighting equipment. These Hoodettes are spaced 18 inches apart and placed just back of the glass doors of the case.

SPACING OF REFLECTORS

The spacing of the Hoodette reflector is, of course, dependent upon the intensity of illumination desired and the type of goods displayed. The Tables Nos. 5, 6 and 7 given for the Scoopette, on page 183, may be used in selecting the number of spacings for the Hoodette reflector also.

Fig. 356. The way in which the Hoodette distributes the light in the wall case.

SPECIAL USES FOR SCOOPETTES AND HOODETTES

DESK LIGHTS, MUSIC RACK LIGHTS, ETC.

Although the Scoopette and Hoodette were originally designed for the lighting of show cases and wall cases, there are many ways in which these little reflectors may be employed. They have, on various occasions, been used for lighting of bookcases in libraries, pictures, bookkeepers' desks, blackboards, bulletin boards, bank cages, music racks, drafting tables, for cove lighting, etc. Some of these are illustrated on the following pages.

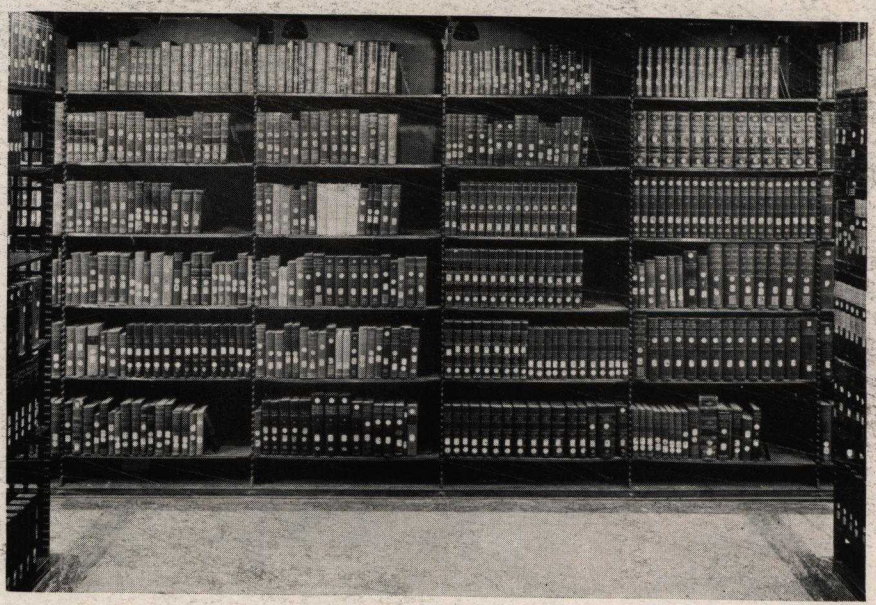


Fig. 357. Book stacks in alcoves of main reading room, Library of Congress, Washington, D. C.

FILING CASES LIGHTED WITH HOODETTES

One of the many special uses for Hoodette equipment is shown below in the day and night views of a filing case lighted with these reflectors. The Hoodettes are mounted on special arms or brackets made of ordinary conduit pipe and fittings at the top of the case. The Hoodette units in this instance are spaced 24 inches apart and are 24 inches out from the case.

BOOKRACK LIGHTING WITH SCOOPETTE

In the original photograph from which the above cut was made, the titles on the books can be easily read indicating that a sufficient intensity of uniform lighting is delivered by the *Scoopette* from the top to the bottom shelf.

These book racks are located in the alcove of the main reading room of the Library of Congress, Washington, D. C. Note that exposed light sources are entirely eliminated, thus reducing the glare and making easy the selection of any particular volume on the shelves.

A total of 240 Scoopettes were installed for the book racks in the alcoves; these racks are 6 feet 6 inches high, the Scoopettes are on 2-foot centers and use 15 watt Mazda lamps.

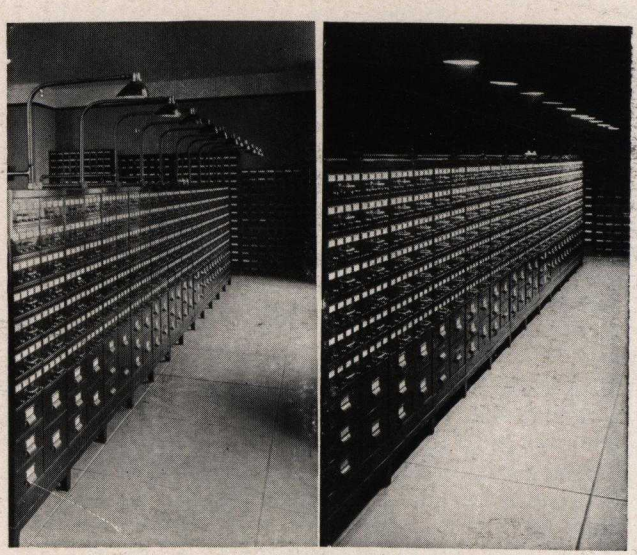


Fig. 358. Day and night views of filing cases lighted with Hoodettes.

THE BRACKETTE

The Brackette consists of a Scoopette fitted on a standard lever key socket with a plate which fastens the unit to the cover of the outlet box.

Fig. 359

The hinge between the plate and the socket is adjustable, making it possible to direct the light at almost any angle. This fitting is finished in black nickel.

The diagram below illustrates the method of installing the Brackette over the tables in bank cages where this unit has had a very successful application, having been standardized by a number of bank architects.

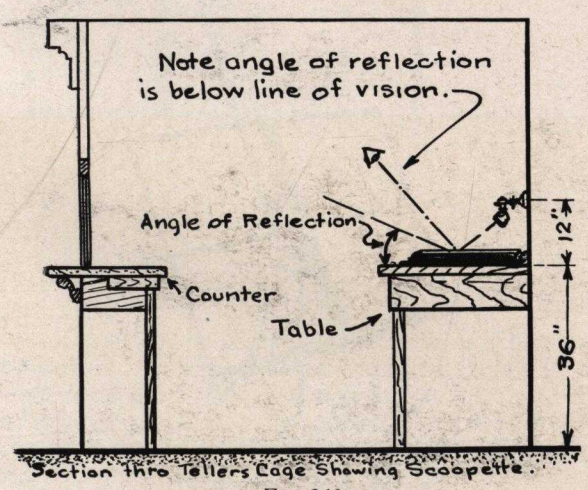


Fig. 360

The unit is usually installed on the pilaster of the bank screen and at a height so that the angle of the reflected light does not cause glare in the eye of the bookkeeper or teller. The Brackette uses a 15- or 25-watt round bulb standard base lamp.

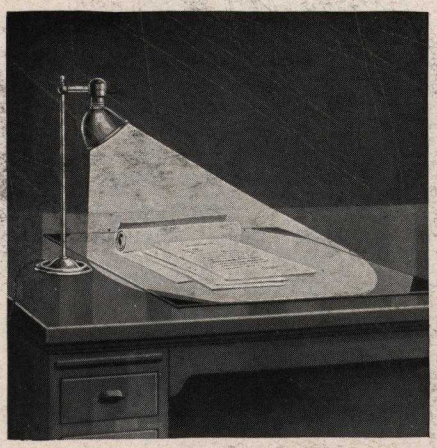


Fig. 361

THE DESKETTE

The Deskette is especially useful to those employed at places difficult to light or when the general office illumination is not used. The height of the standard is such as to prevent the direct light from the lamp shining into the eyes of anyone seated at the desk. The distribution of light from the unit is about as illustrated above. The unit is easily adjusted and can be made to suit any ordinary desk lighting condition. The 15-watt or 25-watt G18½ round bulb standard base lamp may be used in the Deskette.

Fig. 362

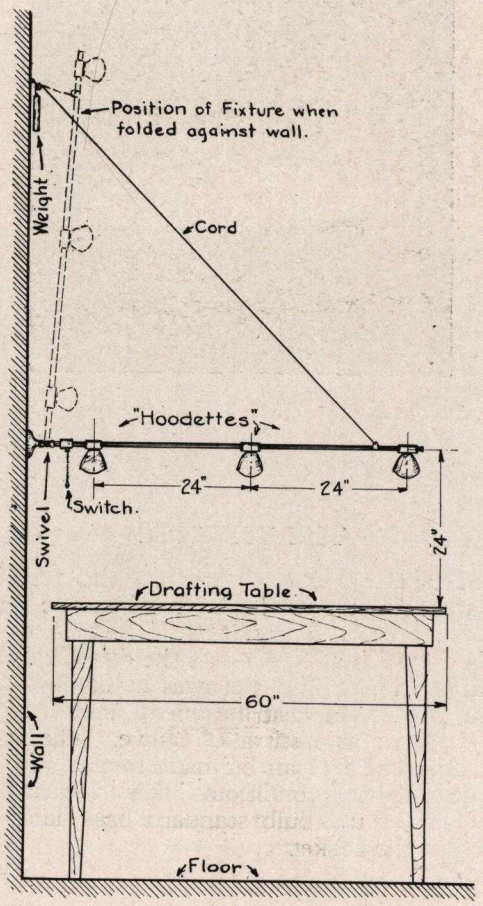


Fig. 363.

DRAFTING TABLE FIXTURE

The above figure illustrates a device made up with Hoodette reflectors used very successfully for drafting table lighting. The diagram shows the position of the outfit as it is used, and also by dotted lines the position of the fixture when folded against the wall. The center of the rods supporting the Hoodettes is 24 inches above the level of the table at a sufficient height to evenly illuminate the surface of the table and at the same time shield the lamp from view. The three units are controlled by means of a pull switch located near the swivel hinge. Standard Scoopette and Hoodette fittings are used in making up this drafting table fixture.

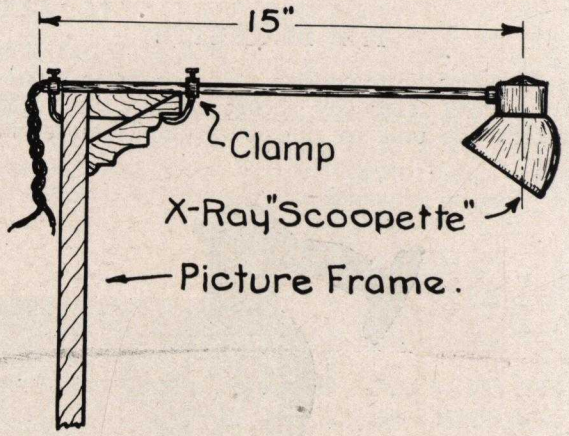


Fig. 365.

PICTURE FRAME LIGHT

The above figure illustrates a simple method of using the Scoopette for picture frame lighting. Two small clamps fasten the rod bracket to the frame of the picture. The wiring is carried through the tubing and to an outlet on the wall.

Fig. 364.

MUSIC RACK UNIT

This unit consists of the Scoopette reflector with a special bracket and attaching device which will fit the ordinary music rack. The spread of light from the Scoopette is especially well suited to the illumination of the music sheet, at the same time concealing the lamp from the view and thus preventing glare. The lever key socket allows each rack lamp to be individually controlled.

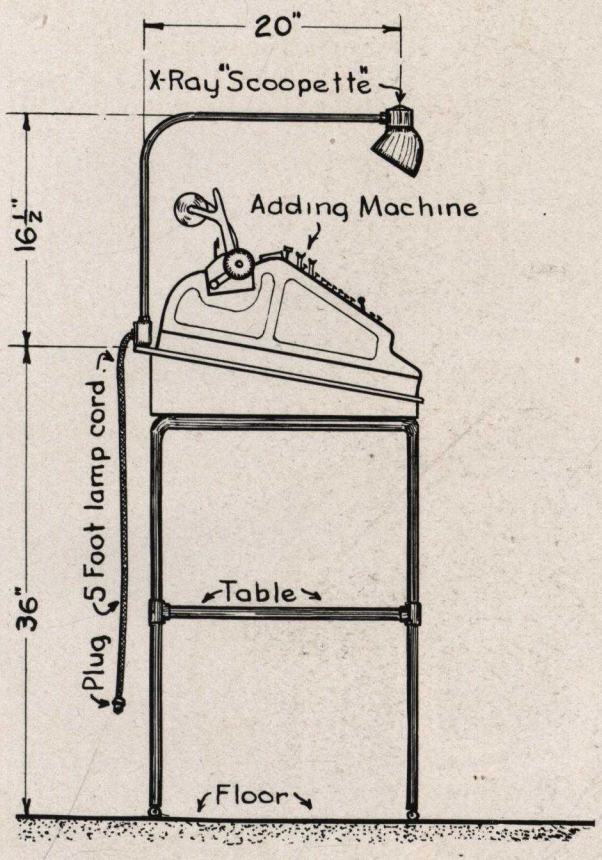


Fig. 366.

UNIT FOR ADDING MACHINES

A local light over adding machines is sometimes desirable. A very efficient unit can be made up with a standard Scoopette and a short piece of bent tubing fastened into an ordinary conduit fitting as shown in the illustration above. When supplied with 5 feet of lamp cord the unit can be attached to floor outlet or an outlet in the base board.

PIANO LAMP

A lamp made up as illustrated in the diagram below has the advantage of casting an even lighting over the music sheet, and at the same time concealing the source of light entirely from view. The unit is small and, therefore, inconspicuous. The Scoopette unit itself is very small, only 3 inches from front to back and from the top of the socket to the bottom of the reflector only about 4½ inches. The wiring connections are made the same as for the ordinary piano lamp.

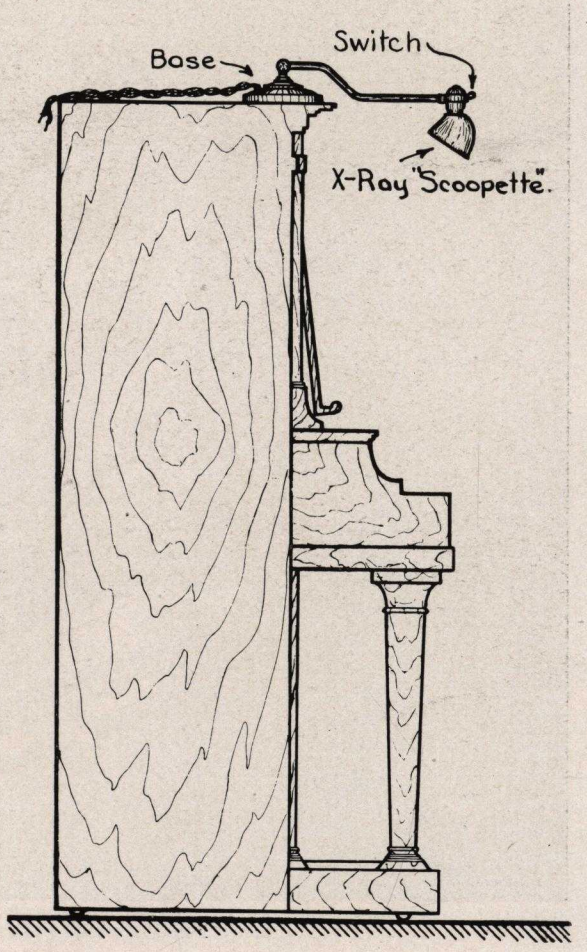


Fig. 367.

Fig. 368. Flood Lighting of Z. L. White Company's Store, Columbus, Ohio.

XIV FLOOD LIGHTING

USES AND UNITS FOR FLOOD LIGHTING—METHODS OF FIGURING

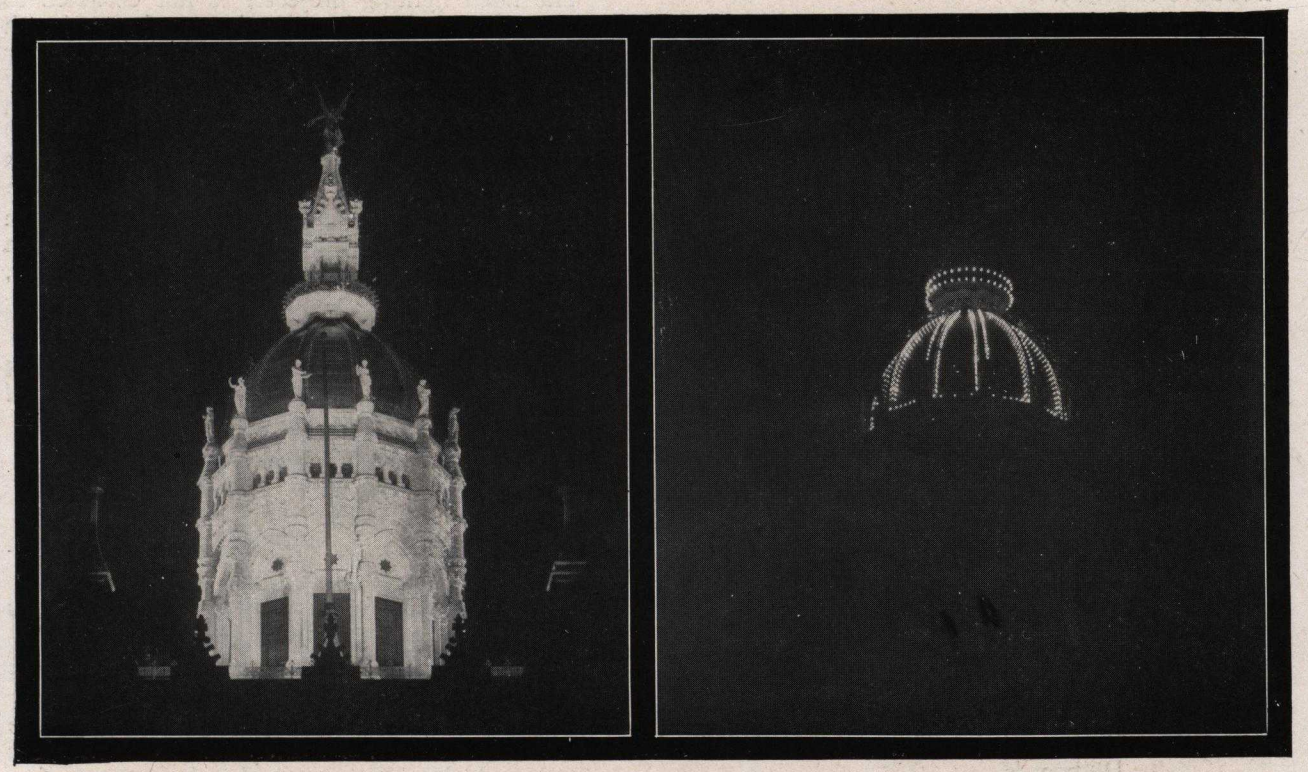


Fig. 369. Dome, Connecticut State Capitol, Hartford, Conn., with flood lighting and with studded lights.

THE first large applications of flood lighting were for the production of spectacular and decorative effects. These were soon followed by its use for advertising purposes in the lighting of public buildings, signs, billboards and amusement parks. This new lighting method, which only a short time ago was considered more or less novel, has taken on a more permanent character and promises soon to become a necessary part of the equipment for railroads and industrial establishments.

Doubtless the finest instance of flood lighting on a large scale was the illumination of the Panama Pacific Exposition, but the flood lighting of the tower of the mammoth Woolworth Building by means of X-Ray projector reflectors was an equally important achievement, since it demonstrated to the world more vividly the grand effect obtainable when an imposing architectural edifice is brought into striking relief against the background of the dark sky.

Flood lighting was immediately recognized as a new, striking, artistic and dignified means of advertising a building. Architects became enthusiastic about it because it brings out the beauty of the design almost better than daylight.

The scheme of using bare lamps for outlining the building has been used for a great many years and some pleasing results have been secured thereby. It was not possible to get the daylight effect, however, until the recent perfection of flood lighting. Outline lighting is satisfactory in some cases. It does not accentuate the architectural features of the building but rather obliterates details of design. Outline lighting has its place, however. In some instances, the most effective results are obtained by combining this method with that of flood lighting.

With the development of flood lighting, civic organizations, county, state and national governments became interested in the lighting of public buildings, monuments and other architectural gems which were concealed to the eyes of the public by night. Central stations at once promoted flood lighting as it meant attractive additional load and more than that, it gave them desirable publicity. Energetic contractors realized attractive profits on

unexpected contracts for making flood lighting installations and also came in for their measure of free advertisement.

As a result, we find many office buildings, banks, store buildings and theatres the country over illuminated at night with flood lighting projectors. Architects are often willing to alter architectural details so that flood lighting may be employed on the buildings they design. In some instances, special cornices are constructed and in other cases, architects extend marquees out from the building for the accommodation of the projectors.

Flood lighting can be installed at a small expense. It does not mar the surface of the building since in most cases the lighting units can be located across the street or at a considerable distance away from the building in an accessible location.

The uses to which flood lighting can be put are almost unlimited. Some of the most important applications are as follows:

City Halls
County Court Houses
Public Libraries
State Capitol buildings
Office buildings
Banks
Store buildings
Theatres
Amusements
Signs
Billboards
Posters
Industrial plants
Yards
Docks
Loading platforms
Munition plants
Arsenals
Prisons
Bridges
Night construction work
Night excavating
Athletic grounds
Drill grounds
Rifle ranges
Trap shooting grounds
Toboggan slides
Bathing beaches
Race tracks
Open air theatres
Outside stages
Football grounds
Flags.

UNITS FOR FLOOD LIGHTING

With flood lighting, the illumination is thrown upon the lighted object from a distance. This requires the use of a projector employing mirrored reflectors of special design.

The flood lighting projector is not designed to throw a concentrated beam such as is obtained with a searchlight or locomotive headlight, but rather to spread the light evenly over a comparatively large area. A suitable unit, if located 50 feet from the ground and directed at an angle of about 30 degrees below the horizontal, will cover an area on the ground about 40 feet in width and 80 feet long.

Projector units are now obtainable for use with lamps from 200 watts up to 1500 watts. Inasmuch as these units are used almost entirely out of doors, they should have the following essential features:

1. *Should be well ventilated.*
2. *Weather-proofed in such a manner that the lamp and reflector will not be affected by changes in atmospheric conditions.*
3. *Should be compact.*
4. *Light in weight.*
5. *Easily installed.*
6. *Readily accessible for cleaning and renewing of lamps.*
7. *Capable of adjustment for different spreads of the beam of light.*
8. *Easily adjusted for pointing the beam in any horizontal or vertical direction.*
9. *Above all, the most practical requirement is that the reflector be of correct design, of the highest efficiency, and its reflecting surface be of a permanent nature.*

The X-Ray units for flood lighting are designed to conform to all of the above requirements and are of two general types, those using special flood lighting lamps and those employing standard Mazda "C" lamps.

LAMPS FOR FLOOD LIGHTING

The special flood lighting lamp has been recently perfected for this service. It is a concentrated filament, gas-filled, tungsten lamp of great light giving capacity, made in 250 and 500 watt sizes.

The regular Mazda "C" lamps used for flood lighting are the same as those for standard lighting service and come in sizes from 300 watts to 1000 watts.

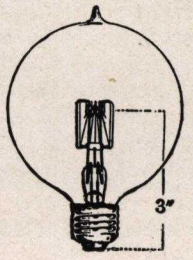


Fig. 370. Lamp for flood-lighting service. G-30 bulb, 250-watts, 110-125 volts. Can be burned in any position except within 45 degrees of vertically, base up.

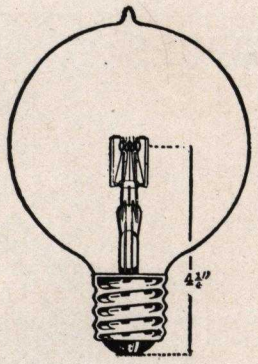


Fig. 371. Lamp for flood-lighting service, G-40 bulb, 500 watts, 110-125 volts. Can be burned in any position except within 45 degrees of vertically, base up.

Lamp Data

250 watt flood lighting lamp—G-30 bulb, 3¾" diameter, 5¼" over all length. Medium screw base, unskirted. Lumens per watt, 11.97. Light center length, 3".

500 watt flood lighting lamp—G-40 bulb. 5" diameter, 7¼" over all length, Mogul base, unskirted. Lumens per watt, 14.96. Light center length, 4¼".

Both of the above lamps may be burned in any position except within 45 degrees of vertically base up.

For information on standard lamps which may be used for flood lighting service, see Figure 217, page 124.

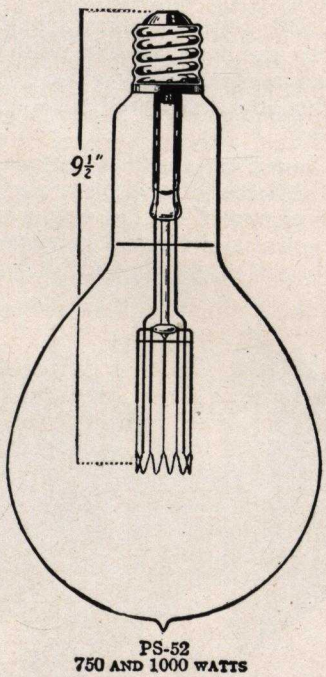


Fig. 372. Standard lamp used for flood-lighting in the X-Ray "MOGUL" projectors.

X-RAY PROJECTORS

X-Ray projectors for flood lighting are shown on the following pages. The unit, No. 51, was the first projector ever designed especially for commercial flood lighting purposes. It contains the No. 800 X-Ray reflector which was made for the installation on the famous Woolworth Tower in New York City.

The X-Ray projectors described in detail on the following pages consist of three distinct series of units.

The No. 50 series uses a 200 or 250 watt round bulb flood-lighting lamp (see Figure 370). These projectors are small, compact, and easily portable.

The No. 60 series is designed for the 400 and 500 watt flood-lighting lamp, and has the advantages of great flexibility both in the matter of adjusting the lamp, and in the interchangeability of reflectors. An extremely wide range of light distribution is possible with this series.

The No. 90 or "MOGUL" series is made for use with standard lamps from 300 watts up to 1,000 watts. The units are adjustable both for focusing and pointing of the beam.

X-Ray Flood Lighting Projectors

No. 50 Series

No.	Lamp	Refl. Class*	Refl. Cat. No.
50	200 or 250w.	d	800
50E	200 or 250w.	e	810
51	200 or 250w.	d	800
51E	200 or 250w.	e	810
	No. 60 Series†		
60C	400 or 500w.	c	840
60D	400 or 500w.	d	835
60E	400 or 500w.	e	845
62C	400 or 500w.	c	840
62D	400 or 500w.	d	835
62E	400 or 500w.	e	845
	No. 90 Series		
91C	300 to 1000w.	c	825
91D	300 to 1000w.	d	827
91E	300 to 1000w.	e	827
92C	300 to 1000w.	c	825
92D	300 to 1000w.	d	827
92E	300 to 1000w.	e	827

*Reflector class—"c" indicates concentrating reflector.
—"d" indicates distributing reflector.
—"e" indicates widely distributing reflector.

†Projector of the "60" class can be adjusted to accommodate the 200-watt and 250-watt flood lighting lamps also.

Fig. 373. Table showing the completeness of the X-Ray line of flood-lighting projectors.

THE NO. 50 PROJECTOR SERIES

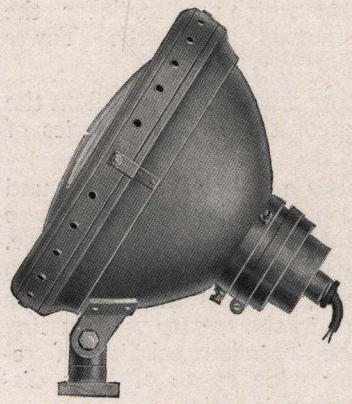


Fig. 374. No. 51 X-Ray projector for 200 watt and 250 watt flood lighting lamp.

Fig. 375. Illustration showing how easily the lamp may be removed from the No. 51 projector.

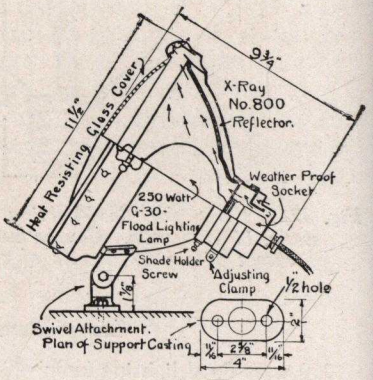


Fig. 376. Diagram showing interior construction of No. 51 unit.

No. 51 Projector

For 200 or 250 watt Flood Lighting Lamp

The No. 51 X-Ray projector was designed for use with the 200 watt or 250 watt G-30 Mazda "C" flood lighting lamp and is shown by Figure 370. It consists of an enameled metal casing containing a powerful X-Ray projector reflector, weather-proof socket and focusing device, with universal swivel base. It is thoroughly ventilated in a manner which prevents the entrance of moisture to the lamp or reflector. The glass cover is made of heat resisting glass which withstands extreme and sudden temperature changes as would occur were the lamp lighted when there is a coating of snow on the glass. It is not necessary to open the glass door in order to focus the lamp. This may be done from the exterior by merely loosening the adjusting clamp of the socket cover with a screw driver. This permits sliding the cap containing the socket backward or forward thus altering the lamp position until the desired degree of concentration or spread is secured. The universal swivel base permits directing the beam of light in practically any direction, and at almost any elevation except from acute angles downward.

No. 50 Projector

In Figure 379 is shown the No. 50 projector which is identical with the No. 51 except for the method of mounting. The No. 50 has a special fork attachment which makes it possible to fasten the unit directly to the end of a ½ inch conduit pipe.

Reflectors

The reflectors for the No. 51 X-Ray projector are shown in Figure 377.

The No. 800 is the reflector ordinarily supplied with the unit and the one most suitable for general flood lighting service where the 200 or 250 watt lamp is used.

The No. 810 reflector gives a more spreading distribution to the light and is used where units can be placed comparatively close to the lighted object and when it is desired to light a comparatively large area.

It will be noted by the illustrations below that the No. 800 reflector has a plain surface whereas the reflecting surface of the No. 810 is broken up by a system of spiral and vertical corrugations similar to those employed for other types of X-Ray reflectors.

No. 800 reflector *No. 810 reflector*

Fig. 377. Reflectors used in the No. 51 projector.

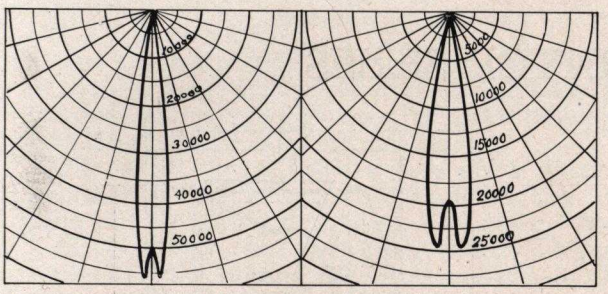


Fig. 378. Curves showing the distribution of light from the No. 51 projector reflector with a 250-watt flood lighting lamp and No. 800 reflector.

Curve above shows greatest concentration of light with No. 800 reflector.

Angle	Candle Power
0	48250
1	53700
2	57600
3	52000
4	37200
5	22800
6	14620
7	6120
8	3090
10	1110

1235 lumens delivered in 0-6° zone.

Curve above shows the greatest spread of light with No. 800 reflector.

Angle	Candle Power
0	17700
1	18940
2	23100
3	24200
4	23000
5	21000
6	19150
7	15200
8	11050
10	3470

1420 lumens delivered in 10° zone.

Technical Data

The light from the No. 51 X-Ray projector is delivered in a concentrated beam. Various degrees of concentration may be had with different positions of the lamp. With the center of luminosity of the lamp at the focus of the reflector, the greatest concentration is secured. The distribution of light for this condition is shown in Figure 378. The main beam of the shaft of light is confined to an angle of divergence of about 12 degrees and the maximum candle power is 57,600 with a 250-watt lamp. There is a secondary beam of about 120 degrees in divergence which is the direct light that escapes through the mouth of the reflector without being intercepted.

Moving the lamp forward in the reflector spreads the main beam out until a point ¼ inch in front of the focus is reached. Since the field of illumination begins to show a dark spot in the center after this point is reached, it is not practicable to go beyond it. In Figure 378, the light distribution is also shown with the lamp ¼ inch in front of the focus. The main beam is now spread out to the total divergence of about 20 degrees and the maximum candle power reduced to 24,200.

In some cases, the light of the secondary beam is valueless whereas in other cases, it is of extreme importance. Thus, when the flood lighting of a building or other objects is done from a distance, the secondary beam is ineffective but when the lighting is accomplished from marquees or cornices close at hand as shown on page 223, it does very effective work.

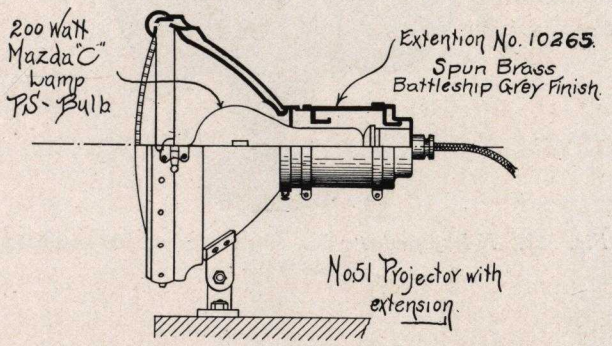
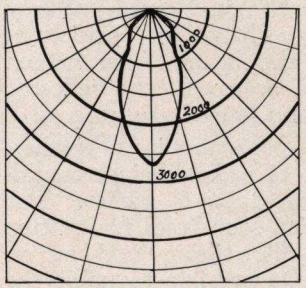


Fig. 380. X-Ray projector No. 51 with extension for adapting the unit for the 200-watt standard Mazda "C" lamp.

Extension Fitting for No. 51 Unit

Figure 380 shows the No. 51 X-Ray projector fitted with a special extension which allows this projector to be used with standard 200 watt Mazda "C" lamp. In some instances, it is desirable to point the unit directly downward. In these cases, the standard lamp should be used in preference to the special flood lighting lamp.

Fig. 379. No. 50 X-Ray projector.



Curve above shows most satisfactory distribution of light with No. 810 reflector.

Angle	Candle Power
0	2580
5	2470
10	2230
15	1930
20	1600
25	1260
30	915
35	715
40	602
45	503

768 lumens delivered in 0-20° zone.

Fig. 381. Curve showing the distribution of light from the No. 51 projector with 250-watt flood lighting lamp and No. 810 reflector.

THE NO. 60 PROJECTOR SERIES

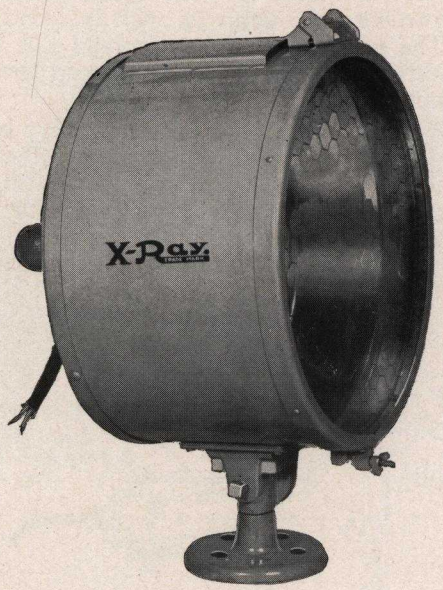


Fig. 382. X-Ray projector No. 60 for 400 and 500 watt flood lighting lamp.

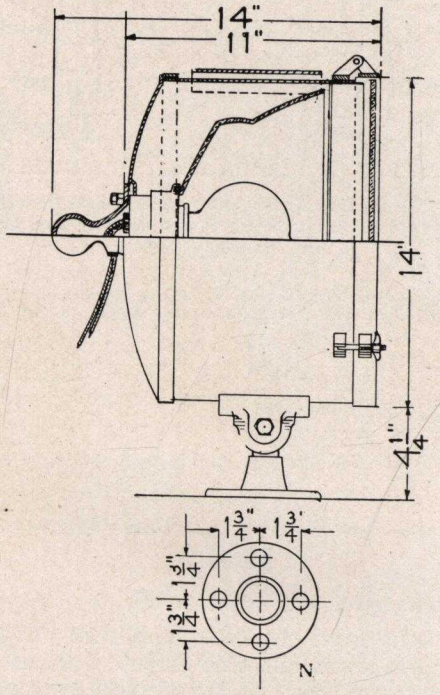


Fig. 383. Diagram showing interior construction of No. 60 projector.

No. 60 Projector

For 400 or 500 Watt Flood Lighting Lamp

The No. 60 projector was designed for use with the 400- or 500-watt G-40 Mazda "C" flood-lighting lamp. Like the No. 51, this projector is made of galvanized steel, finished in neutral gray enamel. The construction of the housing is such as to make the unit thoroughly ventilated and weatherproof. The front cover is of heavy plate wire glass that will withstand all conditions of weather imposed upon the unit in service.

The socket that carries the lamp is in the back of the housing, and is adjustable from the outside. The adjustment can be used not only to properly focus the lamp but also to change its position to vary the divergence of the beam. The hinged front door permits ready access to the reflector for purposes of cleaning and lamp replacements.

The diameter of the projector is 14 inches, depth from front to back 14 inches, height overall 19½ inches, diameter of base 5 inches. The base plate is provided with four holes for bolting to supporting surface. The tilting and swivel feature of the base make it possible to point the projector in any desirable direction except at acute angles up or down. Set screws lock the projector in position.

No. 62 Projector

The No. 62 projector is provided with a trunion support and a heavy spreading circular base 18 inches in diameter. This unit is designed for portable use, whereas the No. 60 is intended for installations where the projector is fastened securely and permanently in place.

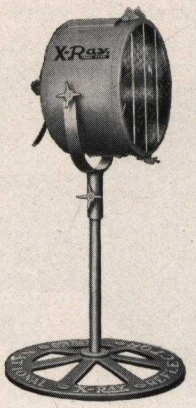
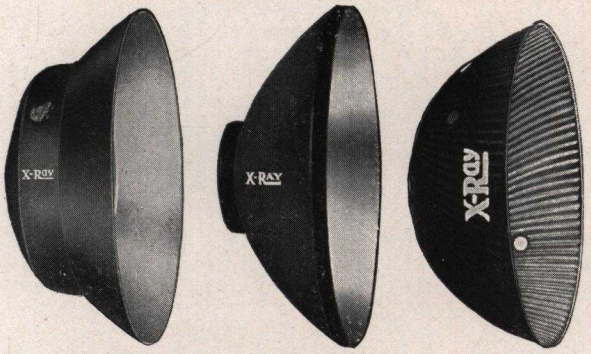


Fig. 384. X-Ray projector No. 62.

Reflectors

An extremely wide range in light distribution is possible with the No. 60 projector, because of the three distinct types of interchangeable reflectors that have been designed for the unit.

The No. 835 is the reflector with which the unit is ordinarily equipped, and is most suitable for general flood lighting purposes. With this reflector a range of beam spread of from 12 to 30 degrees is possible, by varying the lamp position in the reflector.



No. 835 *No. 840* *No.845*

Fig. 385. Reflectors used with the No. 60 X-Ray projector.

The No. 840 reflector produces a concentrated beam, and is used when it is desired to throw the light a long distance and where a strong light must be concentrated on a small area.

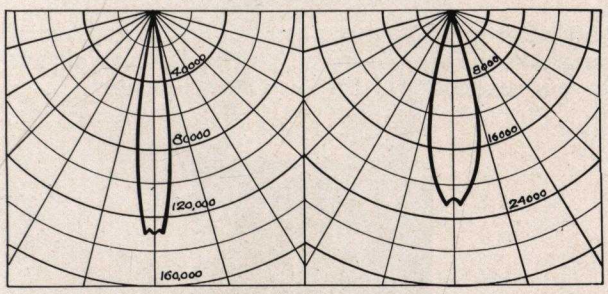


Fig. 386. Curves showing the distribution of light from the No. 835 reflector and 500 watt lamp.

Curve above shows greatest concentration of light with No. 835 reflector.

Angle	Candle Power
0	129000
1	126500
2	130000
3	97500
4	65500
6	22700
8	7350
10	4000
12	2410
14	2010

2440 lumens delivered in 0-7° zone.

Curve above shows the greatest spread of light with No. 835 reflector.

Angle	Candle Power
0	22100
1	22300
2	22800
4	19000
6	19500
8	19500
10	16700
12	10000
14	3340
16	2010

2942 lumens delivered in 0-15° zone.

Reflector No. 845 gives a wide diffused beam, as shown by the curves in Figure 388. This reflector is especially suitable for close-up work, for flooding large areas near at hand, such as for building construction, shipbuilding, excavating, etc.

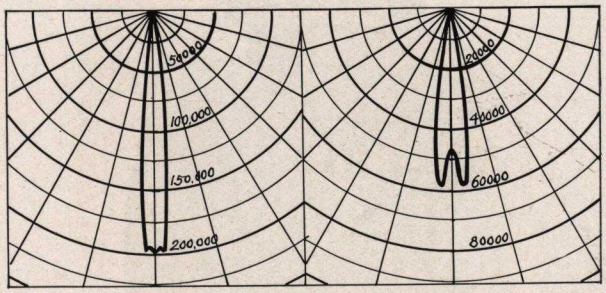


Fig. 387. Curves showing the distribution of light from the No. 840 reflector and 500 watt lamp.

Curve above shows greatest concentration of light with No. 840 reflector.

Angle	Candle Power
0	201000
1	196500
2	198500
3	150000
4	104000
5	36100
6	18700
8	4000
10	1600
12	1070

3030 lumens delivered in 0-5° zone.

Curve above shows the greatest spread of light with No. 840 reflector.

Angle	Candle Power
0	38100
1	37300
2	42800
3	57500
4	59500
5	53500
6	45500
8	28800
10	8020
12	2010

3460 lumens delivered in 0-10° zone.

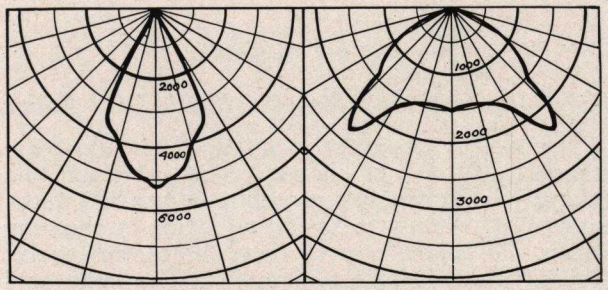


Fig. 388. Curves showing the distribution of light of the No. 845 reflector and 500 watt lamp.

Curve above shows greatest concentration of light with No. 845 reflector.

Angle	Candle Power
0	5350
2	5280
4	5150
6	5020
8	4820
10	4680
14	4270
18	3920
22	3740
26	2740

2460 lumens delivered in 0-25° zone.

Curve above shows the greatest spread of light with No. 845 reflector.

Angle	Candle Power
0	1500
5	1460
10	1460
15	1485
20	1525
25	1550
30	1670
35	2010
40	2270
45	1875

2586 lumens delivered in 0-40° zone.

THE NO. 90 OR "MOGUL" PROJECTOR SERIES

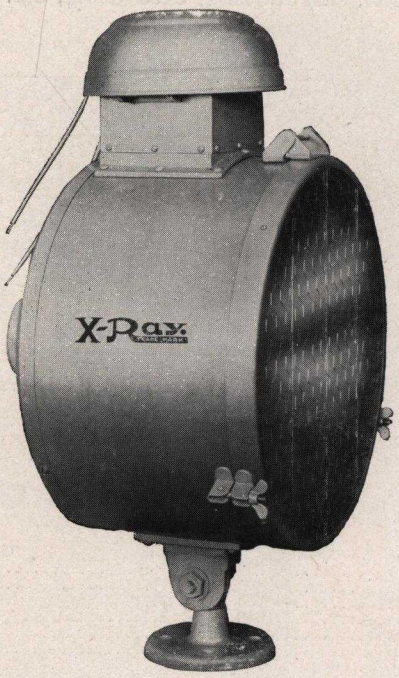


Fig. 389. X-Ray Mogul projector No. 91 for any standard lamp having Mogul base, 300 watts to 1000 watts.

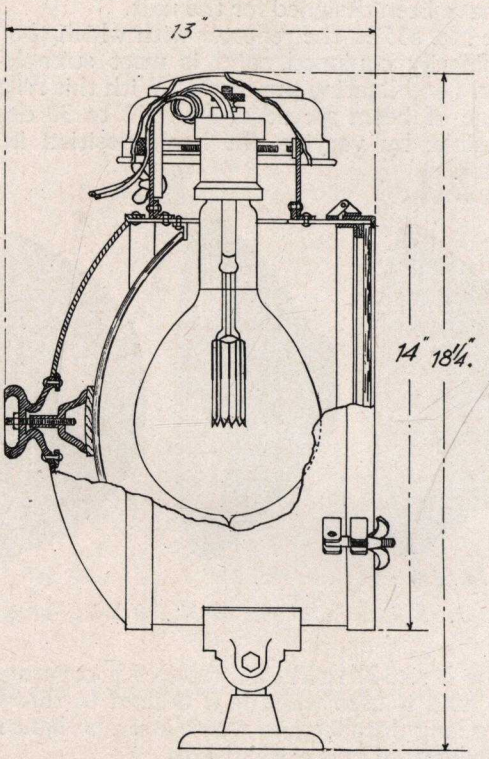


Fig. 390. Diagram showing the interior construction of the No. 91 projector.

No. 91 Projector

For 300 to 1000 watt Standard Mazda "C" Lamp

The No. 91 projector is intended for use with standard Mazda "C" lamps. This projector will take any lamp having a mogul base from 300 watts up to 1000 watts. It has an adjusting mechanism which will enable any of these lamp sizes to be focused properly and accurately. The lamp can be moved forward and backward from the outside, which facilitates very greatly its proper focusing. This unit consists of an enameled metal casing mounted on a swivel base. Several additional parts can be secured which will enable the unit to be properly mounted on brackets, pipe standards, etc. This unit contains a powerful X-Ray reflector shown in Figure 393, weather-proof socket. Like other types of X-Ray projectors, is thoroughly ventilated and at the same time moisture proof. Heavy plate wire glass is used in the front cover. The inside of the barrel of the projector is finished in aluminum bronze. The entire case is zinc plated and is finished on the outside with several coats of battleship gray enamel paint. The front cover is hinged at the top to insure that the door will always have a tendency to stay in a closed position.

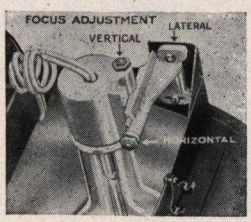


Fig. 391. View of socket adjusting mechanism.

The No. 91 projector is 14 inches in diameter, and 13 inches deep from front to back. The height over all is 19 inches, and the base is 5 inches in diameter. The base has a swivel and tilting motion, which allows the unit to be pointed in practically any direction except within small angles up and down. The adjusting mechanism can be gotten at by simply opening the hinged top.

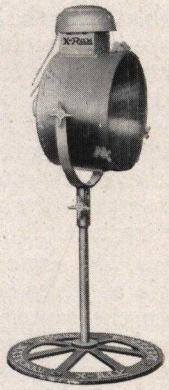
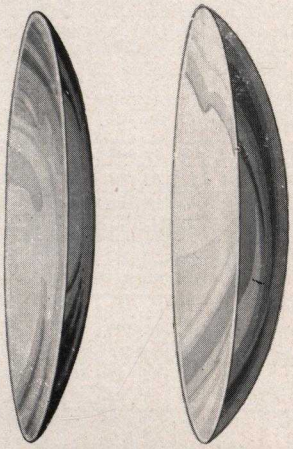


Fig. 392. No. 92 X-Ray projector.

No. 92 Projector

The No. 92 projector, with its trunion support and heavy circular base, is most suitable for floodlighting where the units are to be moved about from one location to another. With this arrangement the beam is quickly pointed by hand in any desired direction. The stand support is also desirable for installing the units behind parapets. The stem may be made any desired length, or omitted altogether, thus mounting the trunion directly to the circular base.



No. 825 *No. 827*

Fig. 393. Reflectors used in No. 91 projector.

Reflectors

Two reflectors of the same diameter have been designed for the No. 90 type of projector. The No. 825 is of the parabolic type, and gives a concentrated beam of light. Reflector No. 827 spreads the light at wider angles than the No. 825, as shown by the diagrams at the right.

Technical Data

The beams from both the No. 825 and No. 827 reflectors are capable of considerable variation by moving the lamp out of focus. The diagrams below show the greatest concentration and greatest beam spread possible with the reflectors and 1,000-watt Mazda "C" lamp.

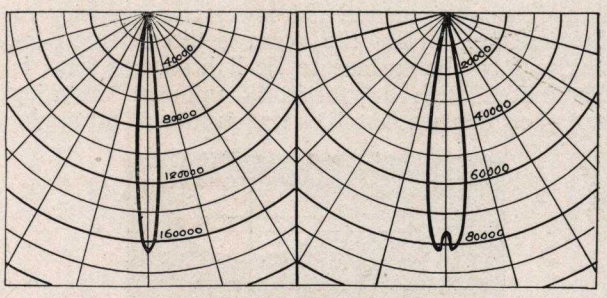


Fig. 394. Curves showing the distribution of light from the No. 825 reflector and 1000-watt lamp.

Curve above shows greatest concentration of light with No. 825 reflector.

Angle	Candle Power
0	166500
1	158000
2	138700
3	91300
4	64500
5	40800
6	38700
7	34400
8	23600
10	9670

3360 lumens delivered in 0-8° zone.

Curve above shows the greatest spread of light with No. 827 reflector.

Angle	Candle Power
0	68700
1	78400
2	81500
3	83700
4	74000
5	65500
6	62300
7	49400
8	37600
10	23600

4940 lumens delivered in 0-10° zone.

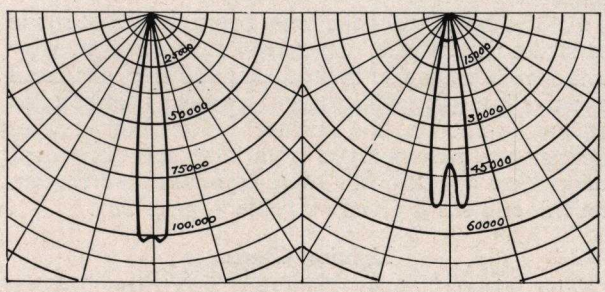


Fig. 395. Curves showing the distribution of light from the No. 827 reflector and 1000-watt lamp.

Curve above shows greatest concentration of light with No. 827 reflector.

Angle	Candle Power
0	100000
1	102000
2	105000
3	108000
4	102000
5	92000
6	67000
8	23000
10	9000
12	7000

4674 lumens delivered in 0-9½° zone.

Curve above shows the greatest spread of light with No. 827 reflector.

Angle	Candle Power
0	34000
1	32000
2	43000
4	50000
6	42000
8	32000
10	25000
12	16000
14	9000
16	5000

4860 lumens delivered in 0-14° zone.

ILLUMINATION DATA FOR X-RAY PROJECTORS

The beam of light from the X-Ray projector is conical and hence when it strikes a surface perpendicularly it illuminates a circular area. On the other hand, if the beam is directed to the surface at an angle as in Figure 396 it illuminates an area which is elliptical in shape. The greater the angle at which the beam strikes, the larger becomes the area of the ellipse and the lower the intensity of illumination. When the beam is directed perpendicularly to the surface to be lighted, the field is illuminated with a practically uniform intensity but when the beam strikes the surface at an angle,

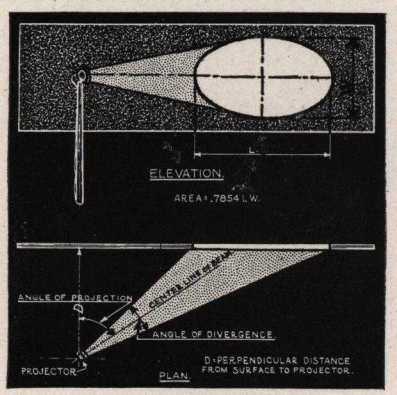


Fig. 396. Area illuminated when beam of light strikes surface at an angle.

the portions of the field nearest the projector are brightest and the remote portions less bright. The greater the angle of projection, the greater this difference.

All the light flux of the main beam should be made to strike the surface. By over-lapping beams, very uniform illumination is produced and the calculated average intensity will closely represent that secured at any point on the surface. The foot candles intensity to be employed is variable and dependent upon local conditions. More complete information on this subject is given in Table 9, page 205.

Lighting Charts

The charts given for the various X-Ray projectors give the length and width of the area illuminated and average foot candles intensity of illumination for various angles of projection to various projecting distances from the surface. Tables are given for each type of X-Ray projector having different angles of divergence of the beam. The square feet area given in the tables for the illuminated field may be obtained from the formula, area equals .7854xLxW. The value of illumination intensity represents the average over the entire field and of course is a lower quantity than the intensity at the center or narrow portions of the illuminated field.

All data in these tables is for the lamp and reflector only and does not take into account, the absorption of light in the glass cover of the housing. The clear glass cover supplied with the X-Ray projectors absorbs about 15% of the light flux, allowance for which must be made in making calculations. When color screens are used over projectors, account must be taken of the absorption of these screens when calculating the resulting intensity.

In the tables below, the angle of projection corresponds to the angle as given in Figure 396, that is, the angle between the center line of the beam and the perpendicular line D. The distances 50 feet, 100 feet, 300 feet, etc., are the distances from the projector to the illuminated surface measured on the center line of the beam. The charts in most cases show values of L and W for two degrees of beam spread. As explained on previous pages, the different degrees of spread are obtained by adjusting the position of the lamp with respect to the reflector. Refer to the curves on pages 197, 199, and 201.

Charts for No. 50 Series

REFLECTOR №800 WITH 250 WATT G-30 FLOOD LIGHTING LAMP
Length (L) and width (W) or area illuminated and average foot candle (F.C.) intensity.

ANGLE OF PROJECTION	DIST. 50 FT.			DIST. 75 FT.			DIST. 100 FT.			DIST. 200 FT.			DIST. 300 FT.		
	L.	W.	F.C.	L.	W.	F.C.	L.	W	F.C.	L.	W.	F.C.	L.	W.	F.C.
FOR BEAM SPREAD OF 12°															
0°	10	10	15.0	15	15	6.69	20	20	4.0	40	40	.94	60	60	.42
15°	12	11	11.4	18	16	5.2	23	22	3.1	48	44	.71	72	66	.32
30°	13	11	10.5	20	17	4.4	26	23	2.5	52	45	.64	78	68	.29
45°	15	12	8.35	23	18	3.8	30	24	2.1	60	48	.52	90	72	.23
60°	21	13	5.8	31	19	2.7	42	26	1.3	84	52	.34	126	78	.15
FOR BEAM SPREAD OF 20°															
0°	17	17	6.2	34	34	1.5	51	51	.69	69	69	.37	86	86	.23
15°	18	18	5.5	35	36	1.4	53	54	.62	71	72	.35	89	90	.21
30°	20	19	4.6	40	38	1.2	60	57	.53	80	75	.30	100	95	.10
45°	25	22	3.3	50	41	.88	75	62	.38	100	82	.22	125	103	.02
60°	38	25	1.8	76	49	.48	113	73	.23	150	97	.14	186	120	.01

Fig. 397. Table showing areas illuminated by X-Ray No. 51 projector with candle power values, reflector No. 800.

REFLECTOR №810 WITH 250 WATT G-30 FLOOD LIGHTING LAMP.
Length (L) and width (W) or area illuminated and average foot candle (F.C.) intensity.

ANGLE OF PROJECTION	DIST. 20 FT.			DIST. 40 FT.			DIST. 60 FT.			DIST. 80 FT.			DIST. 100 FT.		
	L.	W	F.C.	L	W.	F.C.	L.	W.	F.C	L	W.	F.C	L	W.	F.C
FOR BEAM SPREAD OF 40°															
0°	14	14	5.0	29	29	1.1	43	43	.53	56	56	.31	71	71	.19
15°	15	16	4.0	31	32	1.0	45	48	.45	60	63	.26	75	81	.16
30°	17	18	3.2	33	36	0.8	50	52	.37	67	72	20	85	91	12
45°	23	22	1.9	47	44	0.43	69	67	.21	92	88	11	114	110	.07
60°	52	43	0.4	104	85	0.1	156	129	.04	208	172	.02	252	223	01

Fig. 398. Table showing areas illuminated by X-Ray No. 51 Projector, with Reflector No. 810.

Charts for No. 60 Series

REFLECTOR Nº 835 WITH 500 WATT G-40 FLOOD LIGHTING MAZDA LAMP.
Length (L) and width (W) of area illuminated and average foot candle (F.C) intensity.

ANGLE OF PROJECTION	DIST. 100 FT.			DIST. 200 FT.			DIST. 300 FT.			DIST. 400 FT.			DIST. 500 FT.		
	L.	W.	F.C.	L.	W.	F.C.	L.	W.	F.C.	L.	W.	F.C.	L	W.	F.C.
FOR BEAM SPREAD OF 14°															
0°	25	25	4.9	50	50	1.2	75	75	.55	100	100	.31	126	126	.19
15°	26	27	4.4	53	54	1.1	78	80	.49	103	108	.28	129	135	.18
30°	30	27	3.8	60	54	.96	90	81	.42	121	112	.23	156	140	.14
45°	35	28	3.2	71	57	.76	105	84	.35	140	114	.19	175	143	.12
60°	53	32	1.8	106	64	.41	159	96	.20	212	128	.11	265	160	.07
FOR BEAM SPREAD OF 30°															
0°	55	55	12.4	110	110	3.3	165	165	1.3	220	220	.76	275	275	.49
15°	57	58	11.1	114	116	2.8	171	174	1.2	228	232	.70	285	240	45
30°	65	64	8.9	132	128	2.2	195	192	.99	260	256	.53	325	320	.35
45°	84	73	6.0	168	146	1.5	252	219	.64	336	292	38	420	365	.24
60°	144	114	2.2	288	228	55	432	342	.25	576	456	.14	710	570	.09

Fig. 399. Table showing areas illuminated by X-Ray No. 60 projector with candle power values for No. 835 reflector.

REFLECTOR Nº 840 WITH 500 WATT G-40 FLOOD LIGHTING MAZDA LAMP.
Length (L) and width (W) of area illuminated and average foot candle (F.C) intensity.

ANGLE OF PROJECTION	DIST. 100 FT.			DIST. 150 FT.			DIST. 200 FT.			DIST. 250 FT.			DIST. 300 FT.		
	L.	W.	F.C.	L.	W.	F.C.	L.	W.	F.C.	L.	W.	F.C.	L.	W.	F.C.
FOR BEAM SPREAD OF 10°															
0°	11	11	3.2	22	22	0.8	35	35	.32	44	44	.20	55	55	.13
15°	12	11	2.9	23	22	.77	38	34	30	47	44	.19	60	54	12
30°	14	12	2.3	29	26	.51	42	36	26	56	48	.14	70	60	.09
45°	15	13	2.0	32	25	.48	45	39	23	60	52	.12	75	65	.07
60°	22	14	1.2	44	28	.25	66	42	.14	88	56	.08	110	70	.05
FOR BEAM SPREAD OF 20°															
0°	34	34	3.8	69	69	.93	102	102	.42	136	136	.22	168	168	.15
15°	35	36	3.4	71	72	.86	106	107	.39	140	143	.22	175	178	.14
30°	40	38	2.9	80	75	74	120	113	.33	159	152	.18	200	188	.11
45°	50	41	2.1	100	82	.54	150	124	.25	199	164	.13	249	205	.09
60°	76	49	1.1	150	97	.30	229	145	13	304	196	.07	380	245	.03

Fig. 400. Table showing areas illuminated by X-Ray No. 60 projector with candle power values for No. 840 reflector.

REFLECTOR Nº 845 WITH 500 WATT G-40 FLOOD LIGHTING MAZDA LAMP.
Length (L) and width (W) of area illuminated and average foot candle (F.C) intensity.

ANGLE OF PROJECTION	DIST. 50 FT.			DIST. 75 FT.			DIST. 100 FT.			DIST. 125 FT.			DIST. 150 FT.		
	L.	W.	F.C.	L.	W.	F.C.	L.	W.	F.C.	L.	W.	F.C.	L.	W.	F.C.
FOR BEAM SPREAD OF 30°															
0°	48	48	1.3	72	72	.60	95	95	.35	107	107	.27	144	144	.15
15°	50	54	1.1	74	81	.52	100	108	.29	113	126	.22	147	161	.13
30°	58	64	0.85	87	96	.37	116	127	.21	130	143	.17	174	192	.11
45°	86	89	0.41	129	134	.18	171	178	.10	193	200	.08			
60°	290	259	.04	435	388	.01	580	517	.01						
FOR BEAM SPREAD OF 60°															
0°	85	85	4.4	128	128	2.0	170	170	1.1	213	213	.73	255	255	.5
15°	95	110	3.0	143	165	1.4	190	220	.78	238	275	.50	285	329	.35
30°	132	168	1.4	198	252	.66	264	336	.37	330	420	23	395	504	.16
45°															
60°															

Fig. 401. Table showing areas illuminated by X-Ray Projector No. 60 with Reflector No. 845.

Charts for No. 90 Series

REFLECTOR Nº 825 WITH 1000 WATT PS-52 STANDARD MAZDA LAMP.
Length (L) and width (W) of area illuminated and average foot candle (F.C) intensity.

ANGLE OF PROJECTION	DIST. 100 FT.			DIST. 150 FT.			DIST. 200 FT.			DIST. 250 FT.			DIST. 300 FT.		
	L.	W.	F.C.	L.	W.	F.C.	L.	W.	F.C.	L.	W.	F.C.	L	W.	F.C.
FOR BEAM SPREAD OF 16°															
0°	28	28	5.5	42	42	2.4	56	56	1.3	70	70	0.87	84	84	0.6
15°	29	30	4.8	44	45	2.1	59	60	1.2	74	75	0.77	88	88	0.55
30°	33	31	4.1	50	47	1.8	67	62	1.0	84	78	0.65	100	95	0.46
45°	41	33	3.1	63	50	1.3	83	67	0.77	104	84	0.49	124	99	0.35
60°	62	38	1.8	92	57	0.81	126	77	0.43	155	95	0.26	187	114	0.2
FOR BEAM SPREAD OF 20°															
0°	34	34	5.4	51	51	2.4	69	69	1.3	86	86	0.85	102	102	0.60
15°	35	36	4.9	53	54	2.2	71	72	1.2	89	90	0.78	106	107	0.55
30°	40	38	4.1	60	57	1.8	80	75	1.05	100	95	0.66	120	113	0.47
45°	50	41	3.1	75	62	1.3	100	82	0.8	125	103	0.49	150	124	0.34
60°	76	49	1.7	113	73	0.8	150	97	0.43	186	120	0.28	224	145	0.19

Fig. 402. Table showing areas illuminated by X-Ray Projector No. 91 with No. 825 Reflector.

REFLECTOR Nº 827 WITH 1000 WATT PS-52 STANDARD MAZDA LAMP.
Length (L) and width (W) of area illuminated and average foot candle (F.C) intensity.

ANGLE OF PROJECTION	DIST. 100 FT.			DIST. 150 FT.			DIST. 200 FT.			DIST. 250 FT.			DIST. 300 FT.		
	L	W.	F.C.	L.	W	FC	L	W	F.C	L.	W.	F.C.	L.	W.	F.C.
FOR BEAM SPREAD OF 19°															
0°	32	32	5.6	49	49	2.5	64	64	1.4	81	81	0.91	97	97	0.63
15°	33	34	5.3	50	51	2.3	67	67	1.3	84	85	0.83	100	101	0.59
30°	37	35	4.5	57	54	1.9	75	71	1.12	94	89	0.71	112	107	0.49
45°	46	38	3.4	71	58	1.4	95	77	0.82	118	97	0.52	141	116	0.39
60°	69	44	1.9	105	67	0.85	139	89	0.48	176	113	0.3	208	133	0.20
FOR BEAM SPREAD OF 28°															
0°	49	49	2.6	74	74	1.1	98	98	0.64	123	123	0.41	148	148	0.28
15°	51	52	2.3	77	79	1.0	103	106	0.56	129	132	0.36	155	158	0.25
30°	58	57	1.8	87	86	0.83	117	115	0.46	147	144	0.29	174	172	0.20
45°	75	65	1.2	113	99	0.55	153	133	0.30	192	166	0.18	227	198	0.13
60°	120	85	0.6	186	131	0.25	253	176	0.13	314	220	0.09	373	262	0.07

Fig. 403. Table showing areas illuminated by X-Ray Projector No. 91 with No. 827 Reflector.

SIMPLIFIED FLOOD LIGHTING CALCULATIONS

A general statement cannot safely be made as to the type and size of unit to be employed for the various requirements. Each individual case should be studied carefully. In general, however, the type of unit using the 200 or 250 watt flood lighting lamp, see Figure 374, is correct for cases in which the projected beam is to be thrown not more than 300 feet. Beyond that, a larger unit with a more powerful lamp should be employed.

The illumination data and distribution curves obtained with X-Ray projectors are given on previous pages. For the practical man, simplified

methods of figuring flood lighting are essential. An estimate of the number of projectors required to effectively illuminate a given surface may be quickly made by obtaining the area of the surface to be lighted and multiplying by the estimated number of watts per square foot required. From the experience of lighting numerous and different subjects, we have gained a definite idea as to the wattage required for these subjects.

In Table 8, are tabulated the watts per square foot recommended for a variety of common objects. Two recommendations are made for buildings, monuments and signs, first for an object located amid poorly illuminated surroundings and second, when surrounded by brightly illuminated objects. As explained below in greater detail, these objects must be flood lighted with a greater illumination when located in a bright neighborhood, whereas when the neighborhood is dark, a lower intensity is equally effective.

Table No. 8

WATTS PER SQUARE FOOT RECOMMENDED FOR FLOOD LIGHTING

Subject to be Illuminated	Poorly Illuminated Surroundings	Brightly Illuminated Surroundings
Buildings and monuments	.33 to 1.50	.66 to 3.0
Signs—over 6′ high	.25 to .50	.5 to 2.0
—less than 7′ high	.75 to 1.50	1.0 to 5.0
Yards of mills, factories and railroads	.02 to .10	.....
Docks, wharves, bridges	.02 to .10	.....
Bathing beaches, playgrounds, etc.	.06 to .20	.....
Athletic grounds	.10 to .25	.....
Outdoor stages	.20 to .30	.....
Cavalry and artillery, drill and parade grounds	.01 to .05	.....
Night construction	.10 to .25	.....

After selecting the wattage per square foot recommended for lighting the given object, it is a simple matter to ascertain the number of projectors to be used.

Example

Suppose for instance, that a storage yard is to be flood lighted from a distance, the yard being 200 feet by 390 feet and located in dark surroundings. The ground area to be lighted is 78,000 square feet. From the table above, we find that about .02 watts per square foot should provide adequate illumination. Multiplying the square foot area by this value gives 1560 watts required. Assuming that a 250 watt projector is to be used, dividing the total watts required by 250 gives 6 as the number of projectors necessary to illuminate the yard.

In case of lighting buildings, monuments, and signs, when the objects to be illuminated are white in color, the lowest values of watts per square foot in the table above can be used. If the buildings are bright yellow or buff in color we should allow twice as many watts per square foot or about .66. Should the building be of medium buff, we should provide about five times the intensity, or about 1½ watts per square foot. Darker colors should be considered poor subjects, no matter how high a wattage might be employed.

The flux of light or lumen method of making calculations may be applied to flood lighting similarly as to direct or indirect lighting. The assumption is made that all the light of the main beam may be made to strike the surface to be illuminated, and by over-lapping the beams, a uniform illumination is produced. The area to be lighted is multiplied by the intensity in foot candles desired, thus giving the number of lumens that must be delivered to the building. From the table under Figure 378 we find that with the No. 51 X-Ray projector unit and the 250-watt flood lighting lamp, 1,420 lumens are delivered in the main beam (Zone 0-10 degrees) when the lamp is at the focus. Dividing the total lumens to be delivered to the building by the lumens in the main beam would give the number of projectors required. The intensity of illumination to be used under different conditions is dependent upon:

First: The color of the surface to be lighted.

A white or cream building reflects light efficiently and hence makes an effective appearance with a comparatively low intensity, whereas, red, brown, and darker colors are poor reflecting substances, and never produce striking results, even with much higher intensities.

Second: The brightness of the surroundings.

If the object is seen against a dark background a low intensity of illumination will suffice to bring the building out in striking relief, whereas if seen against a bright background a higher intensity must be employed.

The intensity to be employed ordinarily is given in the table No. 9. Only the lighter colored surfaces are listed; darker surfaces make poor subjects and even when an exorbitant wattage is employed do not give anywhere near as striking results.

Table No. 9

INTENSITY OF ILLUMINATION IN FOOT CANDLES, RECOMMENDED FOR FLOOD LIGHTING

Subject to be Illuminated	Poorly Illuminated Surroundings	Brightly Illuminated Surroundings
Buildings and Monuments:		
White or cream	2 to 3	4 to 6
Light yellow or buff	3 to 6	6 to 12
Medium buff	6 to 10	12 to 20
Signs	2 to 4	4 to 16
Yards for mills, factories and railroads	.10 to .50	.....
Bathing beaches, docks, wharves, bridges	.10 to .50	.....
Playgrounds, etc.	.25 to 1.00	.....
Athletic grounds	.50 to 1.50	.....
Outdoor stages	1.00 to 2.00	.....
Cavalry and artillery, drill and parade grounds	.06 to .33	.....
Night construction	.50 to 1.50	.....

Example

Suppose we have the front elevation of a bank building to flood light from a distance, the surface is 80 feet high by 60 feet wide and is constructed of white terra cotta. It is located amid dark surroundings. Assume that No. 51 projectors are to be used.

Area to be lighted 80x60 equals 4,800 square feet.

From Table 9 we find that 2-foot candles will give effective results.

4,800x2 equals 9,600 lumens, to be delivered to the building.

Since the projectors are located at an average distance, we will figure on placing the lamp slightly out of focus under which condition 1,420 lumens are delivered in the main beam.

9,600 divided by 1,420 equals approximately 7.

Since so far no account has been taken of the absorption of light in the glass cover, we must make an allowance of 15% for clear glass.

7 divided by .85 equals approximately 8 X-Ray projectors and 250 watt G-30 flood lighting lamps.

Fig. 404. The Tower of the Woolworth Building, New York City, flood lighted at night.

XV APPLICATIONS OF FLOOD LIGHTING

ILLUMINATION FOR BUILDINGS, MONUMENTS, SIGNS, PROTECTIVE LIGHTHING, ETC.

Fig. 405. Fletcher Savings & Trust Bldg., Indianapolis, Ind. Lighted on four sides with eighty-eight projectors placed on surrounding buildings. Vonnegut, Bohn & Mueller, Architects

BUILDINGS

TO uniformly flood the entire surface of a building so that the details of design will be brought out as in daylight, the lighting usually must be done from a distance. The units can many times be placed on the roofs of opposite buildings; usually the most available location for installing.

Another more or less general method is that of locating the projector units upon the building itself. In either case, the flood lighting of the building requires careful planning. After a decision has been made as to the number of projectors that will be needed, it is important to accurately locate them so that the beams will be directed at angles which will insure uniform lighting from the proper direction.

The lighting of the Woolworth Tower shown on the opposite page is accomplished by six hundred X-Ray reflectors and 250-watt flood lighting lamps mounted at various positions on the roof of the main portion of the building and on the towers at various elevations. (See page 222). The entire Tower from the thirtieth to the fifty-eighth stories is bathed in light *from concealed sources* and is visible for miles out at sea.

Office Buildings and Stores

The street faces of the Fletcher Savings & Trust Building are illuminated by means of two banks of projectors mounted on the roof of the diagonally opposite building in the manner shown in Figure 407. The beams of light stream across the street and by careful focusing are made to uniformly flood light the entire building surface. The end elevations are lighted from projectors mounted on adjacent roofs of two story buildings. A total of eighty-eight No. 51 X-Ray projectors are used.

Fig. 406. Night view of the Consolidated Gas, Electric Light & Power Co. Bldg., Baltimore, Md. Parker, Thomas & Rice, Architects

Fig. 407. Day photograph showing the batteries of X-Ray projectors which light the Fletcher bank building installed on roof of building across corner.

When a building can be flood lighted conveniently from the structure itself, this obviously is the most desirable method. Unless conditions are favorable to a successful installation, however, this method should not be employed. The marquee furnishes a good place to locate projectors. The Z. L. White Store (Figure 368) is a splendid example. The face of the building from the second to the eighth stories is lighted with sixteen X-Ray projectors and 250 watt flood lighting lamps. Four additional units at the cornice of the eighth floor intensify the illumination at the top and relieve a tendency toward shadow caused by the projection.

The details of the manner of installing the No. 51s for this installation are given on page 223. A similar installation is shown in Figure 413, but in this case, the marquee does not extend the full width of the building.

The broad cornice at one of the lower floor lines of a building frequently furnishes an excellent location for installing projectors for illuminating the upper part of the building. The Century Theatre in New York City is flood lighted in this manner.

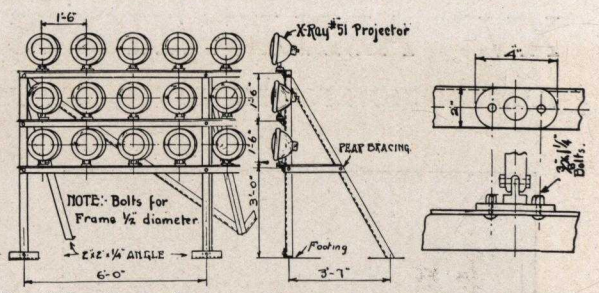


Fig. 408. Type of structural steel supporting frame for X-Ray No. 51 projectors as used in lighting buildings.

A balcony extends across the front of the building at the base of a series of columns and serves as a support and a place of concealing the No. 51 X-Ray projectors.

When projectors are used in this manner, they must be closely spaced to eliminate streaks in the illumination. X-Ray No. 51 units and 250 watt flood lighting lamps located two feet apart give excellent results. However, when this scheme is used, it is not practical to illuminate buildings higher than eight stories.

Frame Supports For Projectors

X-Ray projectors when used to light large surfaces and areas are frequently installed in groups and mounted on a framework. Supporting frames may be constructed of wood or light structural steel, as shown in Figure 408.

The dimensions of frames made up of steel to accommodate the No. 51 projector are given in the Table.

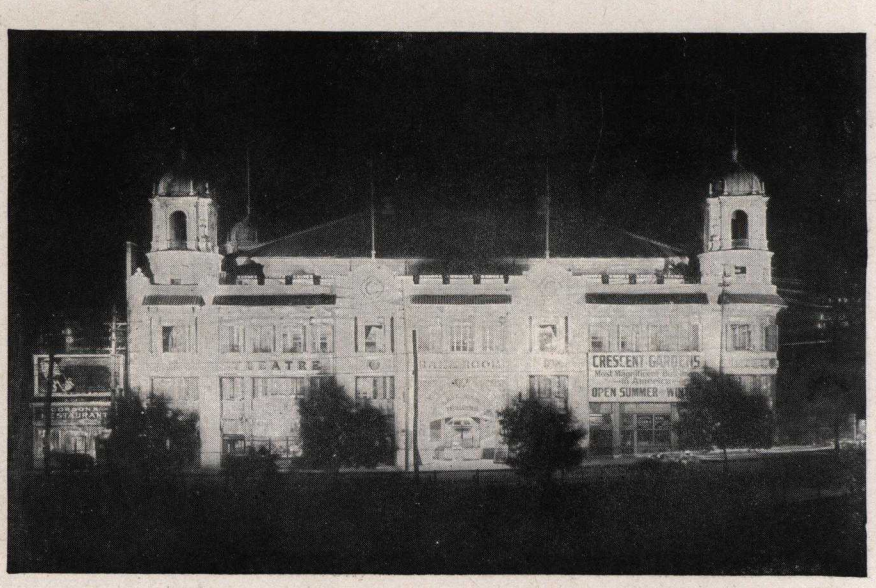


Fig. 409. Theatre in Crescent Gardens, Boston, Mass.

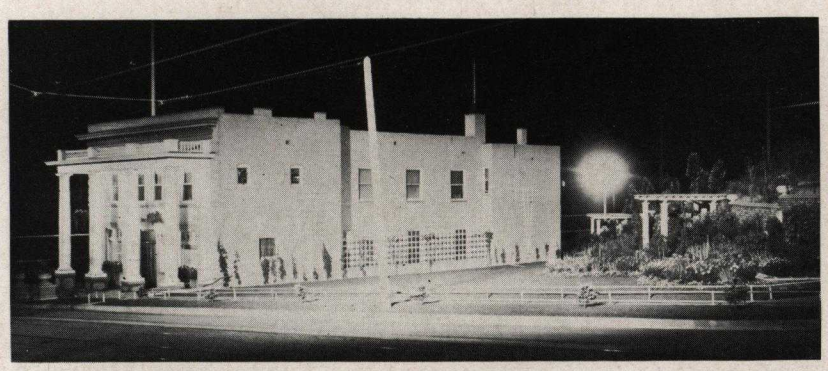


Fig. 410. Mortuary of Mr. George Olinger, Denver, Colo.

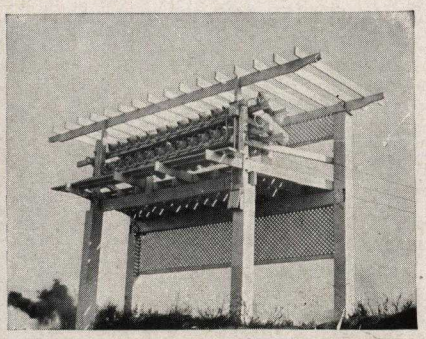


Fig. 412. Pergola type structure supporting projectors.

The frames may be constructed in 6-foot sections and may be carried up to five tiers, thereby accommodating sixteen units in each section. As many sections as necessary may be joined end to end in the manner indicated.

No. of Tiers	No. of X-Ray Projectors for 6-foot section	Height in Feet
1	4	3′ 0″
2	8	4′ 6″
3	12	6′ 0″
4	16	7′ 6″
5	20	9′ 0″

Similar types of frames may be made up for the other types of X-Ray projectors when they are mounted in groups or banks.

In the lighting of buildings it is sometimes desirable to eliminate the secondary beam or spill light (See page 197), especially where the light is thrown from a considerable distance. One method of accomplishing this result is that of employing a long cylindrical tube placed over the mouth of the projector. Thus only the main beam emerges giving a spotlight effect and the stray light is cut off from the intervening space between the projectors and the surface to be lighted. The mortuary shown in Figure 410 is lighted in this way and the means of accomplishing the results are shown in Figure 412. It will be noted that the flood light projectors are cleverly concealed in a pergola type structure across the street from the building. The arrangement of lighting units is indicated in the plan of Figure 411.

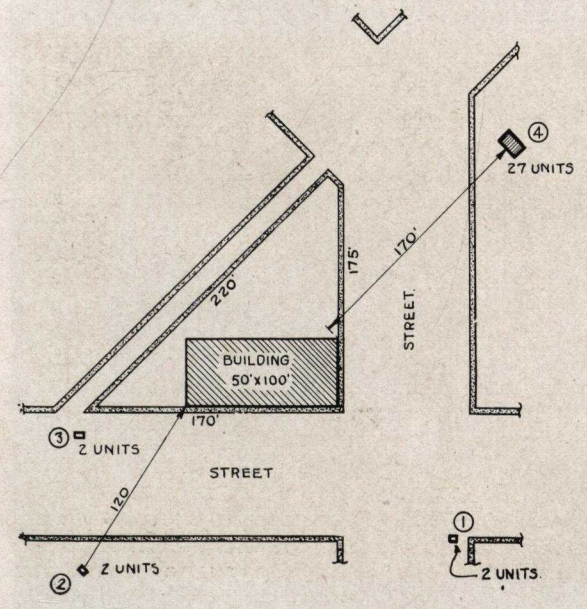


Fig. 411. Plan showing the location of units for flood lighting Denver Mortuary.

Fig. 413. Flood lighting of Ridge Arcade Bldg., Kansas City, Mo. Smith, Rea & Lovitt, Architects

Fig. 414. Soldiers and Sailors Monument, Indianapolis, Ind. Bruno Schmitz, Designer.

MONUMENTS

Monuments ordinarily must be flood lighted from a distance. In some cases, however, it is possible to place units on the base of the monument itself. Two prominent examples of monument lighting are shown here. The night illumination of the Soldiers and Sailors Monument is accomplished by means of four banks of twenty-five projectors, each employing a 250 watt flood lighting lamp, mounted on the roofs of the buildings which surround the circle in Indianapolis, Indiana. The relative location of the units is shown in the plan of Figure 415.

In making this installation care was taken to prevent the main beams from the projectors being pointed into the street on the opposite side of the circle. The result is that from no angle is it possible to look directly into the main beam of any of the units lighting the monument.

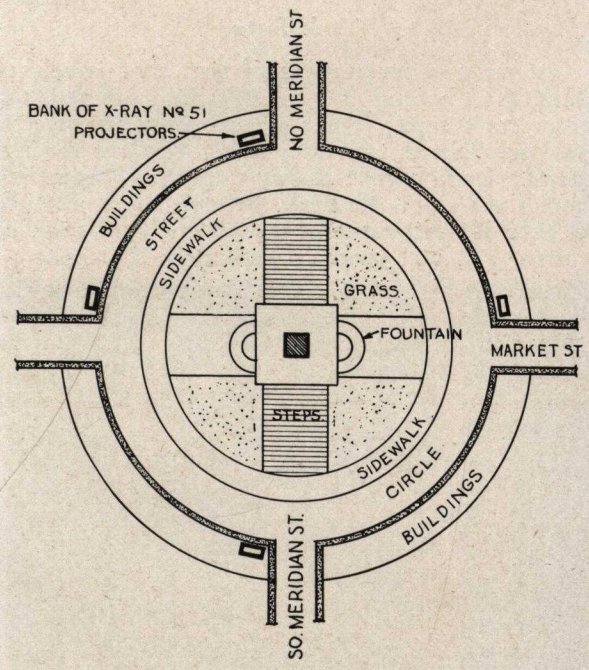


Fig. 415. Plan showing the location of banks of projectors lighting the Indianapolis Monument.

For the Washington Monument in Baltimore, Maryland, all of the projectors are of the X-Ray No. 51 type and are mounted at the base of the monument with the exception of four units. Two of these are located on the roof of the Peabody Institute and two on the roof of the Washington Apartments. Thirty-two units in all are used for the lighting of this monument.

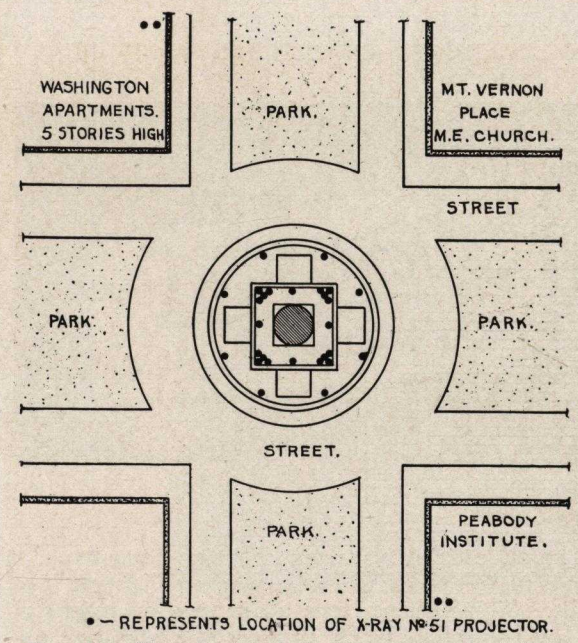


Fig. 416. Plan showing the location of units for lighting Washington Monument, Baltimore, Md.

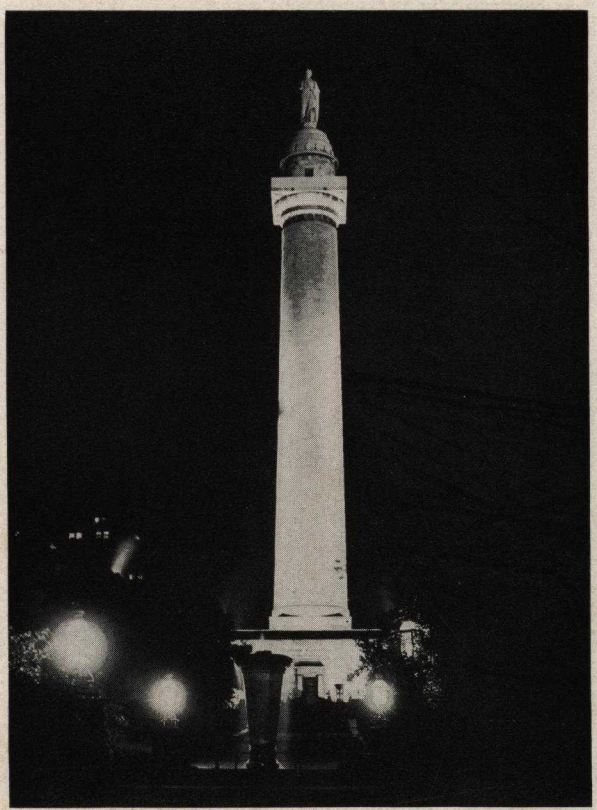


Fig. 417. Washington Monument, Baltimore, Md. Robert Mills, Architect. Built 1815-29.

SIGNS

Fig. 418. Stewart & Company's wall sign, Baltimore, Md.

The advertising value and earning capacity of a sign is more than doubled by properly lighting it at night. Sign lighting from a distance by means of X-Ray projectors has a number of distinctive advantages which makes it a most attractive method.

1. It is possible to uniformly illuminate the sign eliminating the glaring white spots common to ordinary lighting of close up units.
2. A sign may be effectively lighted with a lower current consumption than ordinarily required.
3. The initial cost of the installation is low, because of the few number of projectors required and the speed and ease with which they are set in place.
4. The day appearance of the sign is better, since the lighting equipment is concealed from view.
5. The projectors are easily and quickly moved from one location to another, as old sign contracts expire and new ones are entered.
6. Breakage of lamps during wind storms is negligible, because the projectors are firmly bolted down, and not subject to swaying in the wind.

Fig. 419. Wall bulletin, four stories high in an inaccessible location. Striking lighting with two No. 51 projectors.

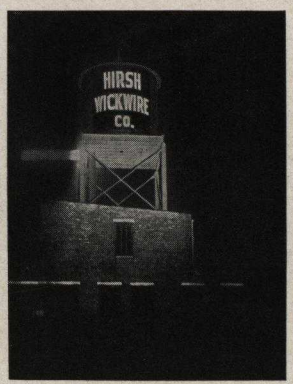


Fig. 420. Tank sign lighted from a distance of 300 feet with two X-Ray No. 51 projectors.

There are so many different types of signs for which flood lighting projectors may be employed that it will be well to cite instances of how a number of typical cases have been handled.

Wall Bulletin Sign

Wall bulletin signs are excellent subjects for flood lighting. Adjoining roofs provide good locations for the X-Ray projectors. The Stewart sign shown in Figure 418 is at the top of a building approximately 125 feet high. The X-Ray units are at a distance of 128 feet away on the roof of another building, as shown in the diagram Figure 421.

The line of the projection is such that one of the intervening buildings cuts off the light squarely at the bottom of the sign. Eight X-Ray No. 51 projectors are used, each with a 250 watt flood lighting lamp. The sign is about 100 feet long and 35 feet high. The current consumption is therefore only about 0.57 watts per square foot.

Tank Signs

One very common type of sign that is seldom illuminated because it is so difficult to get at is the water tank sign. These are conspicuous objects, and well-lighted will earn a big revenue for the owner. One or more X-Ray projectors, depending upon the size of the tank, installed at a distance of 50 to 300 feet on some convenient pole, roof, or window sill, will properly illuminate the tank.

The sign in Figure 420 is illuminated from the nearest accessible point on a roof at about 100 feet below and 200 feet distant. Two No. 51, 250-watt units give highly satisfactory results for this installation. The tank is about 25 feet high and 25 feet in diameter.

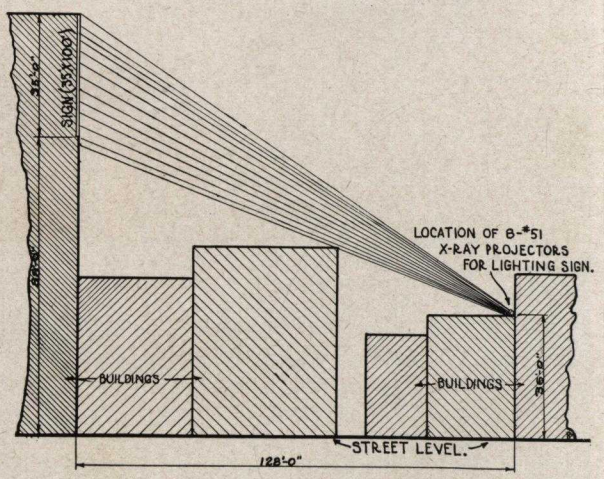


Fig. 421. Diagram showing the location of projectors for the lighting the Stewart & Company sign, Baltimore, Md.

Fig. 422. Night view of the United Drug Company chimney sign.

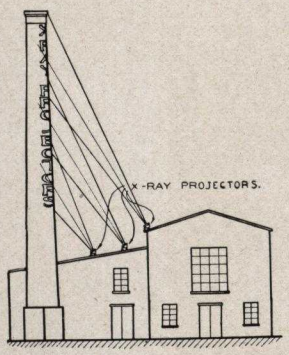


Fig. 423. Diagram illustrating method of lighting chimney sign.

Fig. 424. Day view of the United Drug Company chimney sign.

Chimney Signs

Chimney signs are invaluable when illuminated because they loom up against the dark sky background and are visible for long distances. Usually the roof of the adjoining power house is available, or electric service poles may be installed a distance from the chimney and projectors mounted on them.

Fig. 425. Night view of a sign in Indianapolis, Ind.

A sign which advertises a brand of coffee for the Geiger, Fishback Co., Indianapolis, Ind., is shown in Figure 425. Note that the figure of the boy is surrounded with light from adjacent signs and from the bright illumination of the street below. It was necessary in this case to use a very high intensity of illumination to bring the boy into prominence. Twenty-six No. 51 X-Ray projectors are employed to illuminate this portion of the sign. The units are about sixty feet away. The figure of the boy is 45 feet high and 30 feet wide.

The illustration in Figure 425 shows three distinct methods of night sign lighting, namely, letters outlined with bare lamps, units attached to the sign board, and the flood lighting or projector method.

The advantages of the latter method are at once apparent, inasmuch as the units can be located at a convenient place, even if the sign itself is comparatively inaccessible. The sources of light are entirely concealed, thus avoiding harmful and unnecessary glare. The sign is not marred in appearance by projecting arms carrying local lights.

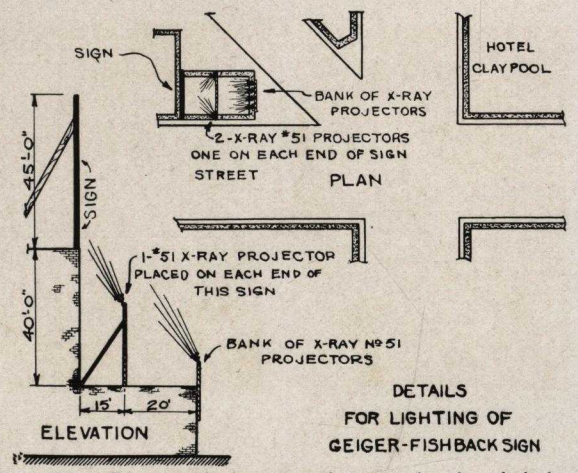


Fig. 426. Plan and elevation showing details of lighting Indianapolis sign.

Fig. 427. Galveston Mills, Galveston, Texas. Protecting a flour mill with five No. 51 flood lighting units. The illumination shown in the picture is from one unit.

Fig. 428. Birds'-eye view of typical industrial plant flood lighted for protection.

FLOOD LIGHTING FOR PROTECTION

Flood lighting units have been found to be the most effective means of lighting zones for protection. For locations difficult to reach with wiring, the light may be projected to a distance of one hundred to one thousand feet. Ordinarily, the cost is less and the maintenance easier than for systems employing a large number of small individual units because of the comparative large areas that can be covered with a single projector.

Although many industrial plants are well lighted inside, very little attention has in the majority of cases been given to the lighting of yards, other than the placing of small bracket lights over entrances and at the corners of buildings. Such conditions are sources of great danger to men who traverse these spaces after dark, and furthermore, leave dark corners wherein intruders can seclude themselves. Marauders shun brightly lighted buildings.

It is difficult and expensive to string overhead wires on pole lines for yard lighting with small reflector units. Projectors, on the other hand, may be installed at small expense on the roofs of buildings, and the yards flooded with illumination. In most cases, no pole lines are needed and maintenance is small and easy. All kinds of industrial establishments, munition plants, arsenals and prisons may now be enclosed in a wall of light through which no one can enter undetected. Projector units

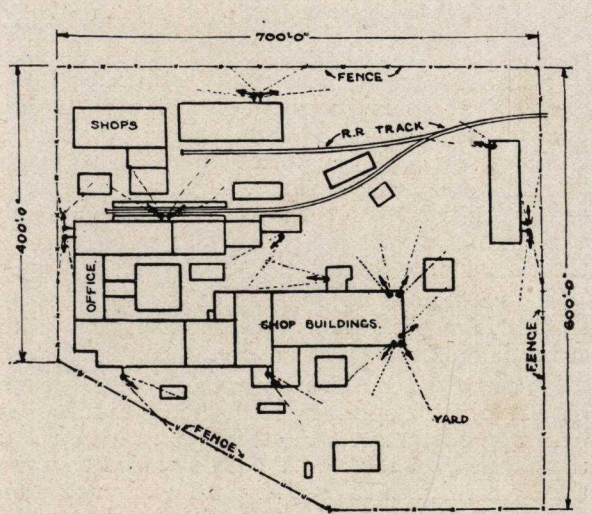


Fig. 429. Ground plan of a manufacturing plant showing position of flood lighting units.

Fig. 430. Union Stockyards, Chicago, Ill. Street entrance to Armour & Company plant.

installed so that they throw very powerful beams of light along the enclosing fence provide the economical means.

Factories, mills, warehouses, wharves and docks involved in the storing and shipping of goods, railroad yards, bridges, canals and locks which have a part in the transportation of manufactured products and food, as well as the stations for the production of gas, electricity and water supply, should be adequately protected after dark.

The accompanying diagrams and illustrations indicate the manner of installing units for a few special cases. A plan for lighting a manufacturing plant showing the location of shop buildings, yards, railroad switches, etc., is given in Figure 429. The arrows indicate the position of the units and general direction of the beams of light. It is necessary to locate the projectors not only with reference to the area to be illuminated but also with reference to the obstructions, such as buildings, watertanks, trees, etc. It will be noted that the units are located on existing buildings. This scheme if it can be utilized makes the installation comparatively economical, as it is unnecessary to erect poles for the placing of the units.

The wiring can be carried to the projector from the inside of the structure where it is entirely out of reach and cannot be tampered with.

Figures 430 and 433 are views in a packing plant district where a systematic scheme of guarding has been worked out. At strategic points throughout the yards, projectors have been installed throwing the light in such a manner that every nook and corner is lighted throughout the night, and patrolling is made as easy and thorough as in the day time. This method of lighting has in many cases released

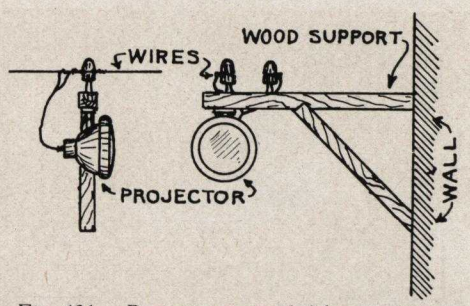


Fig. 431. Projector suspended from crossarm.

for other service men who have been doing patrol duty. With the aid of flood lighting, one can guard more than twice the area he could otherwise.

Fence Lighting

In fence lighting installations, as shown by the diagram in Figure 434, it is necessary to prevent spill-light from falling inside the fence, although it is highly desirable outside. Thus the watchman patrolling inside the fence is constantly in shadow, and is enabled to better see the fence and the area immediately outside.

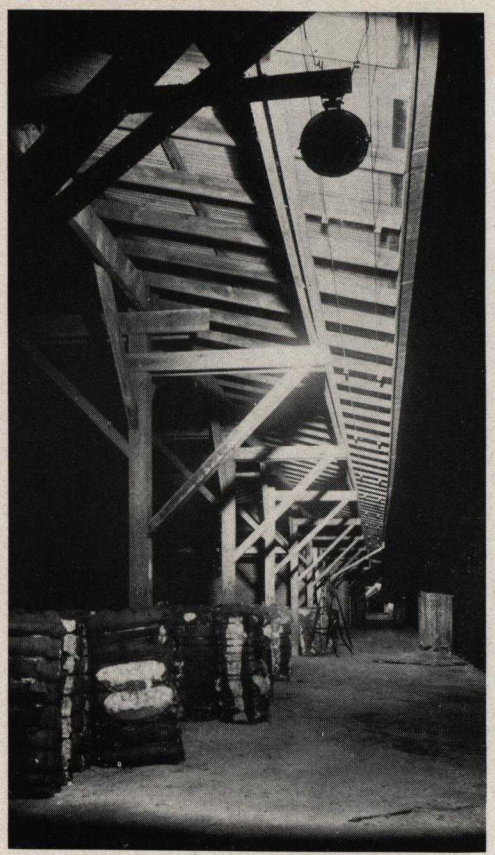


Fig. 432. Shipping platform of cotton warehouse, Galveston, Tex.

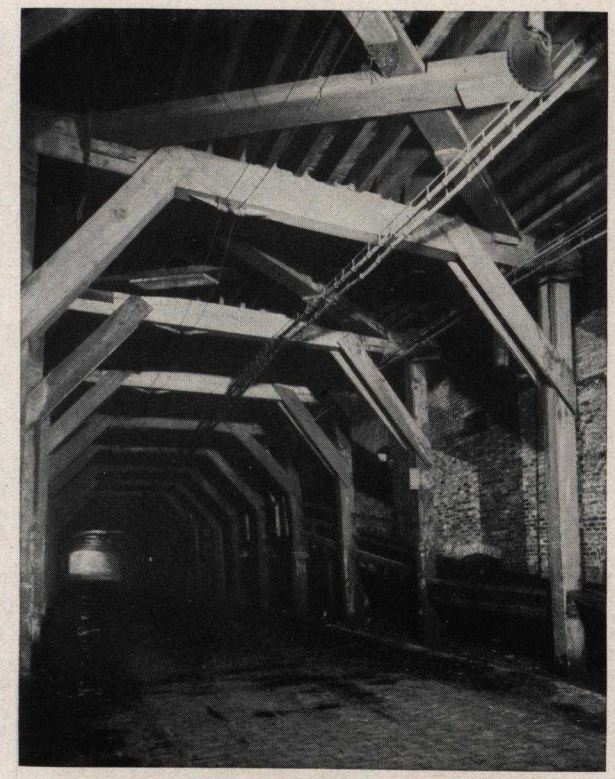


Fig. 433. 42nd Street, Chicago, Ill., inside Swift & Company plant.

For fence protective lighting, a special spill-shield, shown on page 218, in Figure 444, is used, in connection with projector No. 60 or No. 91. This shield is placed in position inside the cover of the unit, and serves to cut off all direct light from the lamp that would naturally fall to the side on which the shield is placed.

A method of mounting the projectors for fence lighting is indicated in the diagram below. The poles supporting the units are inside of the fence and thus the wiring is carried where it cannot be tampered with from the outside. The units are suspended on a bracket to overhang the line of the fence.

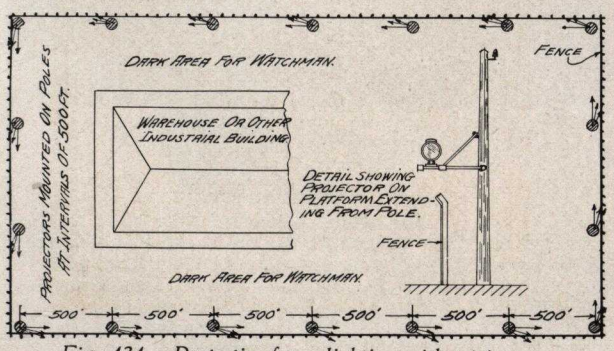


Fig. 434. Protective fence lighting with projectors.

Bridge Protection

Railroad officials, army officers, and others who have had the opportunity to investigate the advantages of flood lighting for bridges have become enthusiastic over this particular application. It has been possible to not only cut down the guard force, but to make the work more effective.

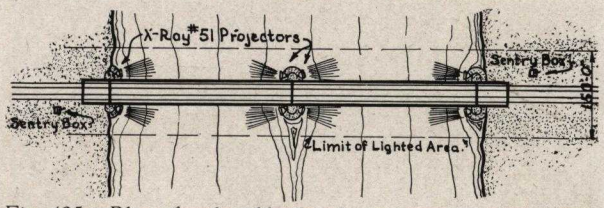


Fig. 435. Plan of railroad bridge showing location of projectors.

A practical method of lighting a railroad bridge for protection is illustrated in Figure 436. The projectors are placed on the concrete piers 8 feet above the water line, with four 200-watt units on each side of the bridge. An area of 150 feet in width and extending the full distance across the river is illuminated. Boats approaching or intruders entering the lighted zone are easily seen, while the guards stationed on the track level remain in darkness.

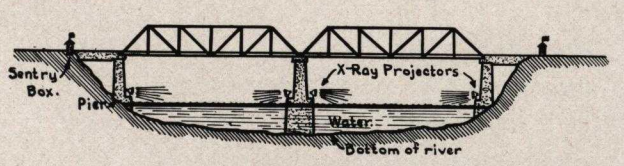


Fig. 436. Railroad bridge protective lighting, showing projectors mounted on piers.

Fig. 437. Bridge approach flood lighted at night.

HOW TO INSTALL X-RAY PROJECTORS.

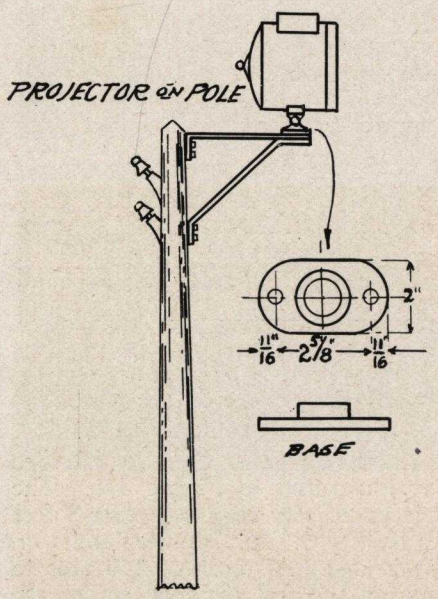


Fig. 438. Method of mounting on poles.

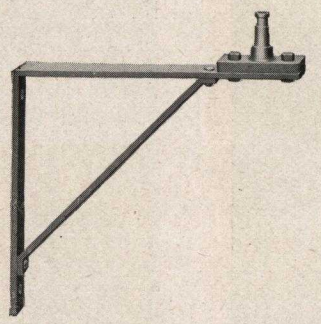


Fig. 439. Wall bracket for mounting projectors on side of building, or on poles.

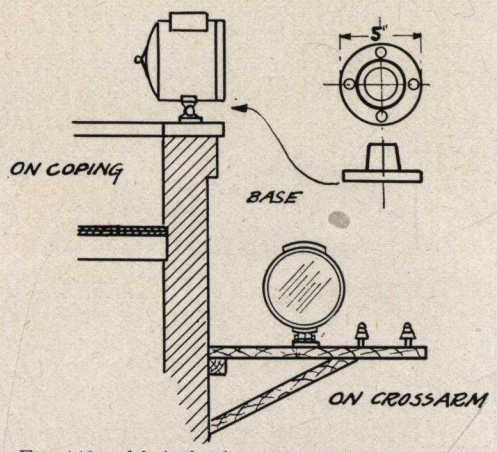


Fig. 440. Methods of mounting projectors with low portable base on coping of buildings, or on cross arms.

The method of mounting X-Ray projectors in any given case will depend upon local conditions. The methods illustrated on this page, as well as that shown on Fig. 431, page 216, are those most usually employed. For floodlighting of buildings the methods of banking the units described on pages 208 and 209 are more suitable. Reference should also be made to the plates on pages 222 and 223, where details are given as to methods of installing units for floodlighting.

For the lighting of buildings, monuments, signs, etc., it is always desirable to conceal the units from view. This is not always possible when floodlighting is used for purposes of protection.

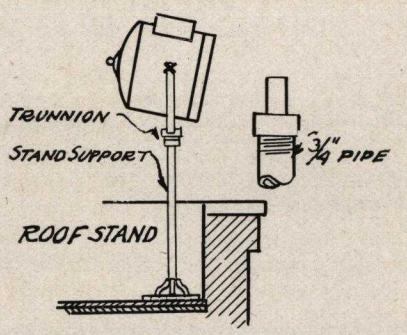


Fig. 441. Method of using stand support for projectors for hand operation, or for placing unit above parapets and other obstructions.

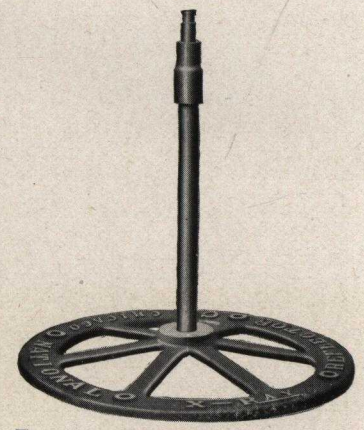


Fig. 442. Portable standard for use with projectors Nos. 51 60 and 91; diameter of base 18 inches.

Fig. 443. X-Ray Projector No. 60, equipped with special spill-shield, for fence protection lighting. *See page 216.*

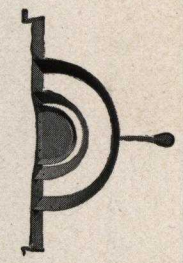


Fig. 444. Spill-shield for use with Projector No. 60 and 62; for eliminating the spill light in fence protection lighting. *See page 216.*

Fig. 445. Standard cover glass for Projectors No. 60, 62, 91 and 92. Similar cover glasses are obtainable with sand-blasted finish, also with a diffusing surface and with a ribbed prism surface.

Fig. 446. The Marigold Gardens, Chicago, Ill. Flood lighted at night.

AMUSEMENTS, PAGEANTS, ETC.

By means of X-Ray projectors athletic grounds, rifle ranges, trap shooting grounds, toboggan slides, bathing beaches, race tracks, outdoor stages and open air theatres may be brilliantly and inexpensively illuminated. Baseball, football and track teams are enabled to put in additional practice if the field is lighted by a few projectors; shooting yards are not limited by the hours of daylight available; night tobogganing is made safe; the joys of swimming are extended by the proper lighting of Municipal and other beaches; night races, outdoor theatricals and pageants become a possibility.

Fig. 447. Summer house, Paragon Park, Boston, Mass.

Football Practice at Night

With the early twilight of the fall, football practice of college squads is usually squeezed into the brief hours between dismissal of afternoon classes and the approach of darkness. Many progressive coaches have, however, stolen a march on rival teams by installing floodlighting on practice fields and so continuing scrimmage work even after the sun has set. The floodlighting units are mounted on the roof of the gymnasium or on the "bleachers" or stadium. In some cases a special pole line carrying the wiring and projectors has been provided.

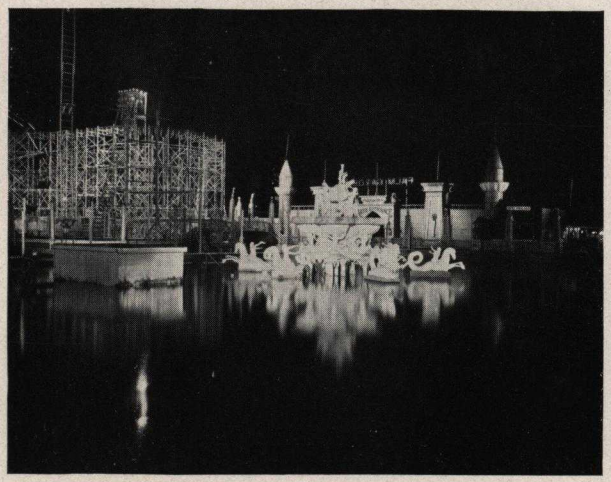


Fig. 448. Fountain, Paragon Park, Boston, Mass.

The illustrations in figures 447 and 448 show how effective results can be produced by bringing into prominence special features in an amusement park. Some of the projectors for illuminating the fountain are easily seen in the picture, mounted in a bank upon the skeleton structure at the left in figure 448. Variety in the lighting can be accomplished by a constantly changing color effect, obtained by using color filters in connection with the projectors.

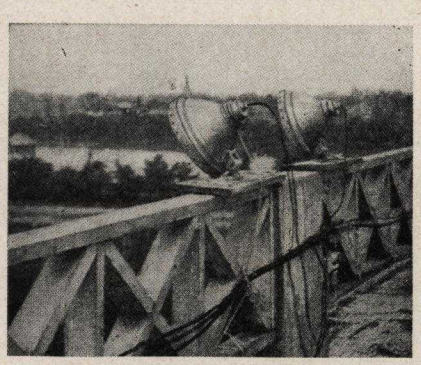


Fig. 449. X-Ray projector mounted for lighting the field at Harvard Stadium.

Additional information on this subject is given under stage lighting on page 148.

Fig. 450

FLAG LIGHTING

The recent increase in patriotic spirit has resulted in the flood lighting of hundreds and thousands of flags at night. For the lighting of the average size flag up to 6 or 9 feet, one or two X-Ray projectors No. 51 will give very effective results. The accompanying table gives the number of 250 watt projectors necessary to properly light flags of various sizes.

The diagrams and Figures 451 and 452 show the proper location of projector units. If the units are installed at 90 degrees to each other and properly directed, the flag will always be in the lighted zone. For large flags, two or more projectors may be located at each of the positions on the diagram. If the surroundings are brightly illuminated, additional projectors should be used in order to bring the flag into prominence.

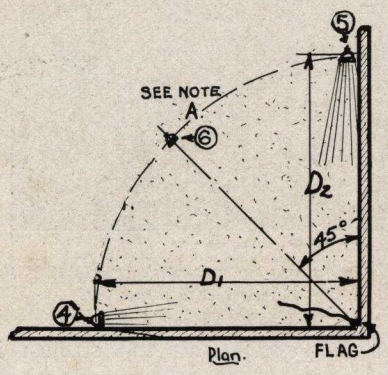


Fig. 451

The methods described on this page for flag lighting can with equal success be applied to the illumination of banners and pennants. Campaign banners and announcements can be made to attract attention at night by floodlighting methods.

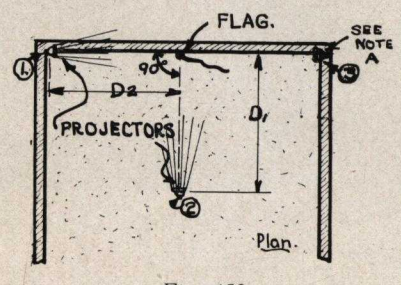


Fig. 452

Size of Flag	Number of Projectors	D_1 and D_2 Feet
4 by 7	2	40
5 by 8	2	50
6 by 9	2	60
8 by 12	4	50
9 by 14	4	60
10 by 16	4	65
12 by 20	6	60
15 by 24	6	70
22 by 30	8	60

Where eight projectors are used, place three at each of the 90 degree positions and the remaining two at the third position shown in Figures 451 and 452.

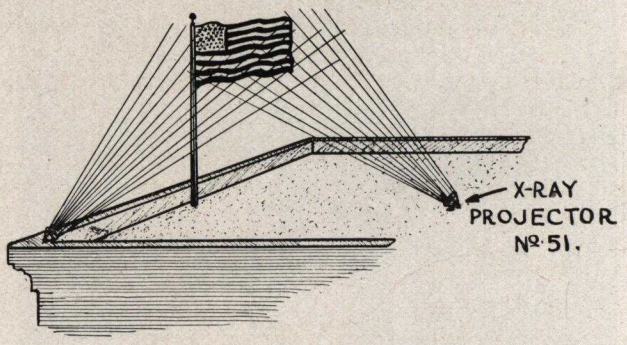


Fig. 453

Note A (refers to diagrams above).—Use this location for two projectors when a total of six is required.

Note B.—When surroundings are brightly illuminated, add two projectors in each case.

Note C.—When eight projectors are used, place three at locations 1, 3, 4, 5, and two at 2 and 6.

For large flags and for those at comparatively great distances away, projectors Nos. 60 and 91 are very suitable.

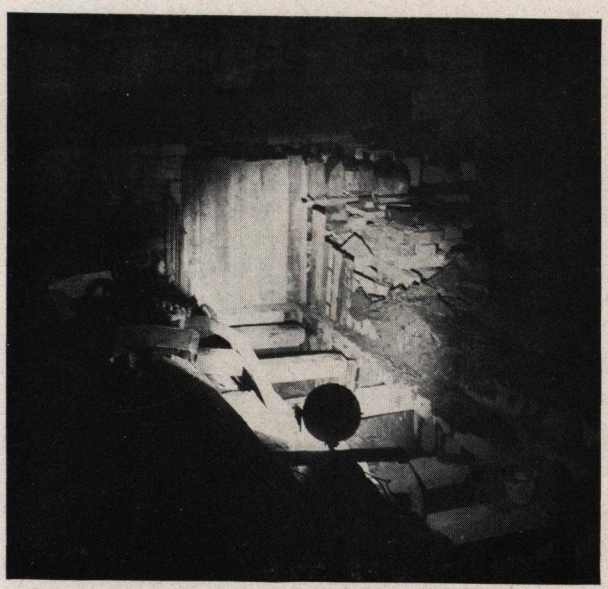


Fig. 454. Flood lighting units enabled the construction work on the Rialto Theatre, Chicago, Ill., to proceed at night.

NIGHT CONSTRUCTION WORK

Night construction has always been difficult and extremely hazardous because of the very limited number of lighting units usually installed in a more or less haphazard way. A few X-Ray projectors located on adjoining structures or on distant points of the building under construction, provide a generous flood of illumination and greatly decrease the hazards of the work. Since the units are readily portable, they may be moved about as the work progresses, or transported from one job to the next. The universal swivel bases with which the X-Ray projectors are equipped, permit changing the direction of the beam of light without requiring a change of location of the projector. In Figure 454 a projector is shown lighting an excavation for a concrete pier of a theatre building.

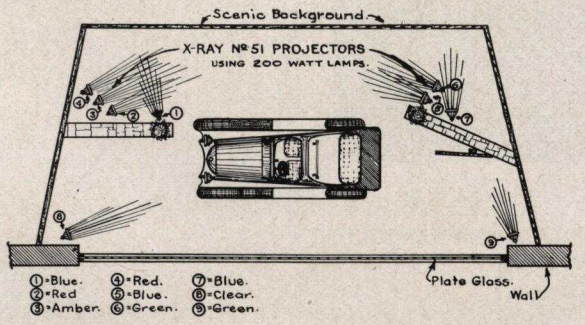


Fig. 455. Plan of special show window display, Overland Motor Company, Chicago, Ill.

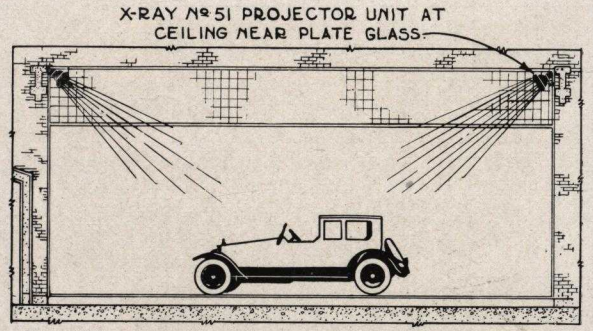


Fig. 456. Lighting a display model with projector units.

AUTO DISPLAYS

A special display method is illustrated in Figure 456. A strong spotlight is thrown on the car by means of two X-Ray No. 51 projectors. The remainder of the showroom is kept in comparative darkness. The attention of the observer cannot help but be arrested by the brilliant display. Because this method of lighting is different, it has more advertising value and at the same time can be accomplished for a fractional part of the current ordinarily employed. It is an especially suitable method for the display of special models.

In Figure 457 is a reproduction of the show window display of the Overland Company, Chicago, when their Country Club model was introduced. The machine is shown stationed at the entrance of the Country Club, which is painted in the background of the setting. The feature in connection with this particular display was the colored light which was thrown upon the background. The diagram in Figure 455 shows the relative location of projector units which were used to throw color rays upon the various details of the background.

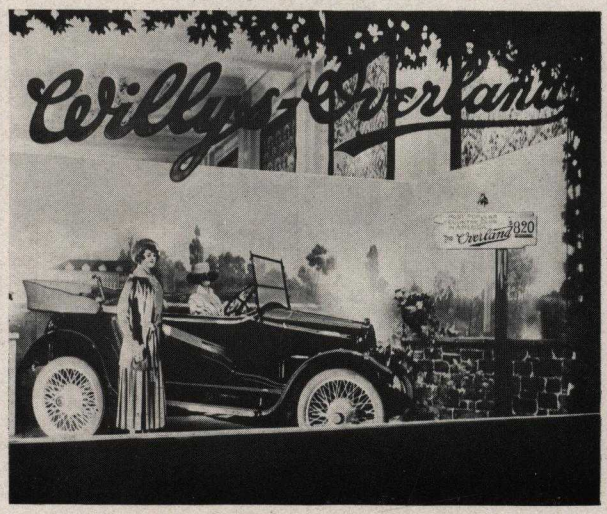
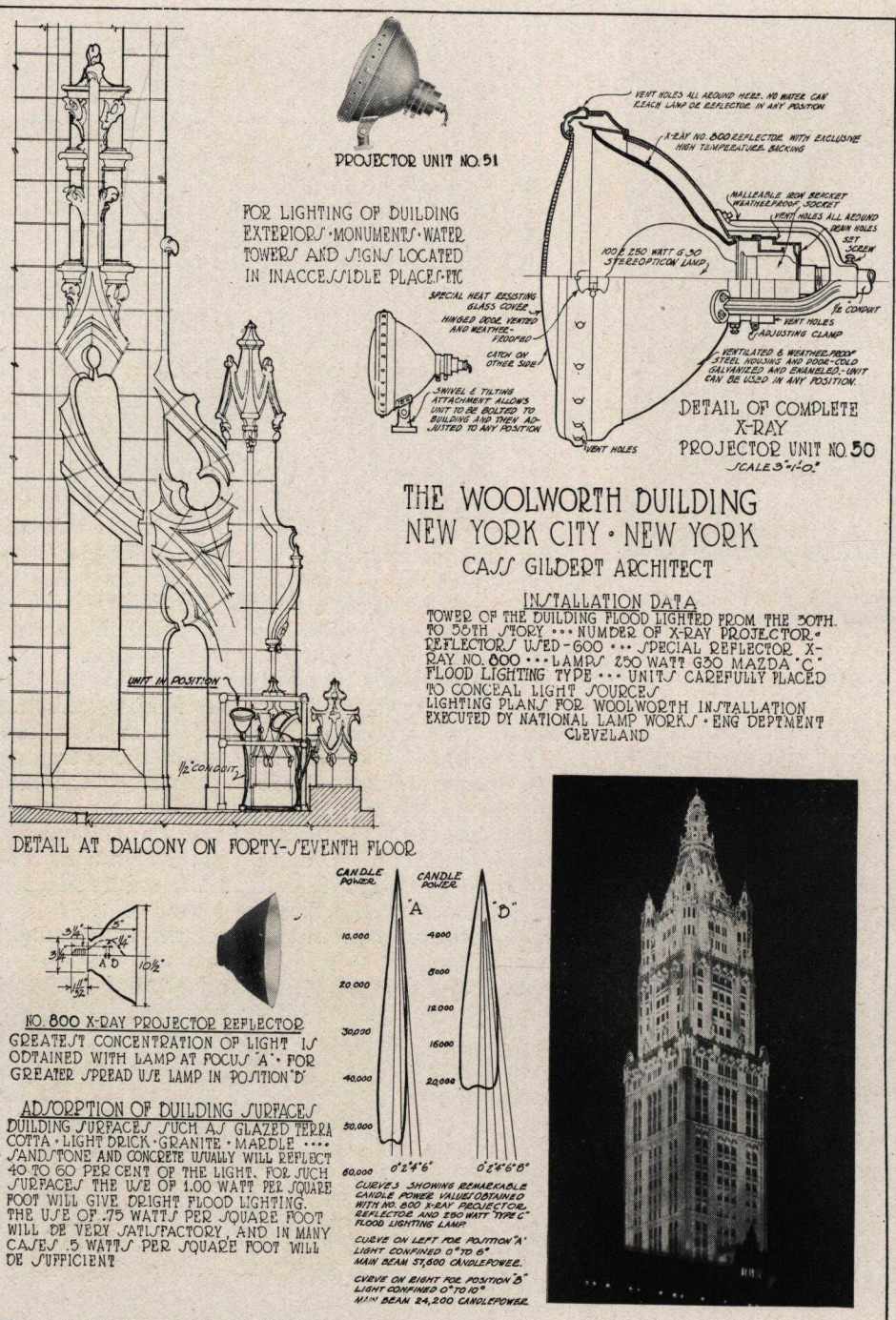


Fig. 457. Display of the Overland Country Club Model, lighted with projectors.



TOWERS

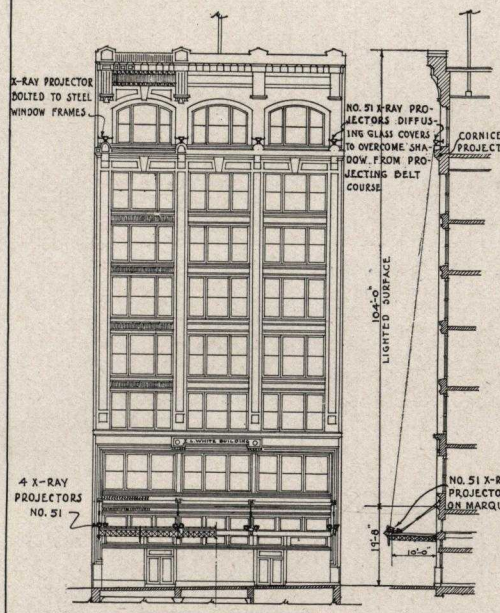
THE FLOODLIGHTING OF TOWERS, MONUMENTS AND OFFICE BUILDINGS, FOR SPECTACULAR AND ADVERTISING EFFECTS, ARE FULLY DESCRIBED ON PAGES 206 TO 213.

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST.

STORES

THE USE OF FLOODLIGHTING CAUSES THE BUILDING TO STAND OUT FROM ITS SURROUNDINGS.

THE UNITS CAN BE PLACED ON THE BUILDING ITSELF OR ACROSS THE STREET. SEE PREVIOUS PAGES FOR METHODS.



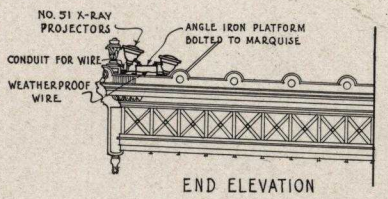
DETAILS SHOWING LOCATION OF X-RAY PROJECTOR UNITS

Z.L.WHITE BUILDING

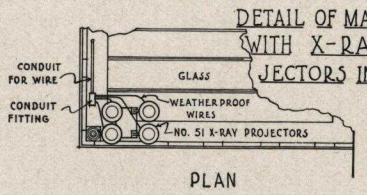
COLUMBUS OHIO

STRIBLING & LUM — AND — WILBUR T. MILLS

ASSOCIATED ARCHITECTS



END ELEVATION



DETAIL OF MARQUISE WITH X-RAY PROJECTORS IN PLACE

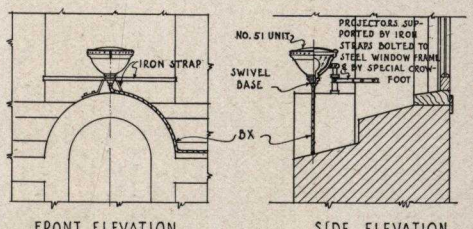
PLAN

INSTALLATION DATA

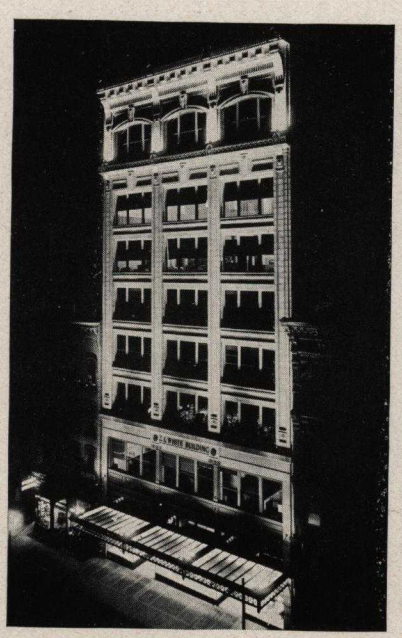
BUILDING — 60'-0 WIDE – 8 STORIES HIGH
BUILDING SURFACE WHITE TERRA COTTA ABOVE SECOND FLOOR LEVEL
104 FEET OF BUILDING HEIGHT FLOOD LIGHTED
6240 SQ. FT. OF SURFACE ILLUMINATED
20 NO. 51 X-RAY PROJECTORS USED – 250 WATT G-30 FLOOD LIGHTING LAMPS
TOTAL WATTAGE 5000 WATTS — WATTS PER SQ. FT. .8

ON MARQUISE — 16 UNITS (IN GROUPS OF 4) ARE ON 3 CIRCUITS FROM CABINET ON FIRST FLOOR — NO. 14 WIRE CARRIED TO UNITS ALL UNITS ON SINGLE SWITCH – 8 UNITS LIGHT UPPER HALF OF FRONT AND 8 UNITS FOR LOWER HALF

ON DELT COURSE – 4 UNITS WITH DIFFUSING GLASS COVERS ON ONE CIRCUIT FROM 8TH FLOOR – WIRES IN CONDUIT TO WINDOW NO. 14 DX ACROSS BUILDING FRONT TO CORRECT UNITS



DETAIL OF PROJECTORS ON DELT COURSE



THE NATIONAL X-RAY REFLECTOR CO. CHICAGO & NEW YORK

A LARGE SIZE REPRODUCTION OF THIS PLATE WILL BE SENT FREE UPON REQUEST

Bank of Buffalo, Buffalo, New York—Above is a view in the public space showing the use of the X-Ray Bank Desk Lighting Units over check desks. The X-Ray Luminous Bowl Fixture for the interior lighting of the Bank is also clearly shown.

The picture above is an interior view in the working space of the bank, showing the installation of the regular X-Ray Bank Desk Equipment for cage lighting and also the use of the X-Ray Bookkeepers' Desk Fixture shown on page 230. The Bookkeepers' Desk Fixture is 13 feet long, has three supports and is equipped with a pull switch at each end.

XVI BANK DESK LIGHTING

TELLERS' CAGES AND BOOKKEEPERS' DESKS.

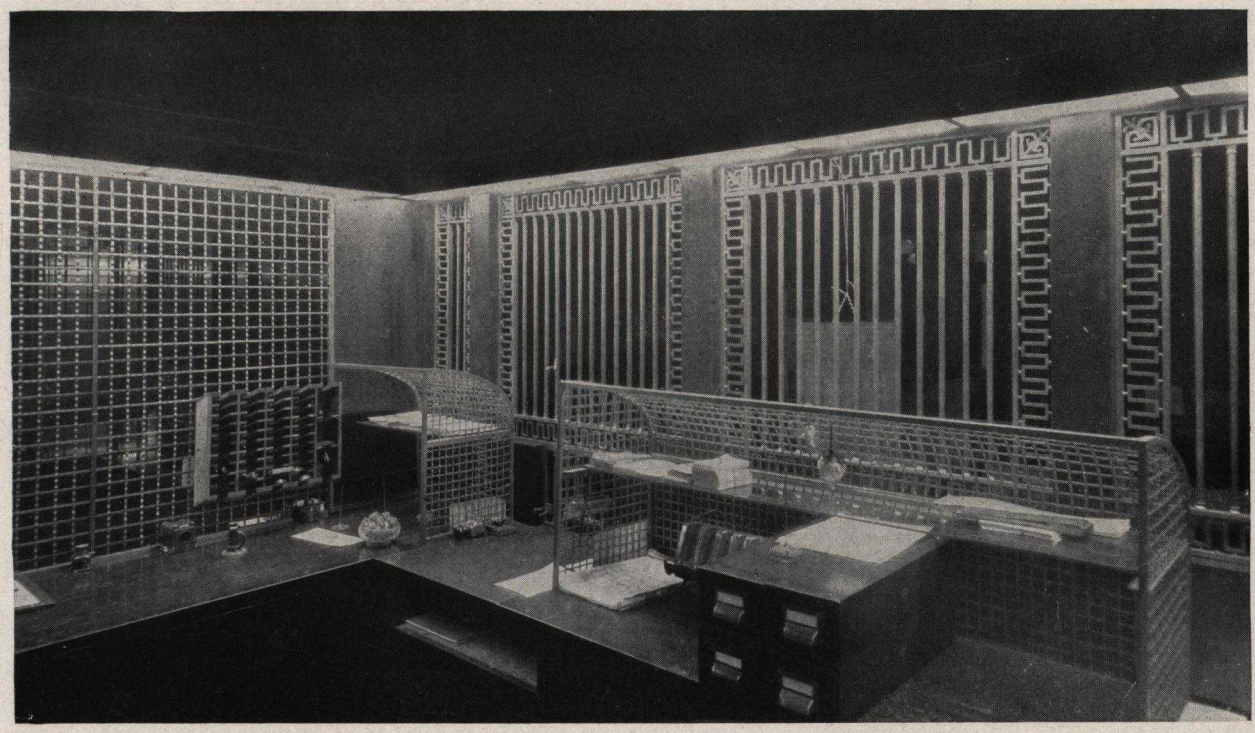


Fig. 458. Interior view of cashier's cage showing the lighting from X-Ray bank desk equipment. City Trust & Savings Bank. Albert Pretzinger and Edward P. Musselman, Architects, Dayton, Ohio.

THE exacting conditions and the particular requirements of the work to be performed in bank cages makes the lighting of them of very great importance. Not only is a high intensity required, but also an even distribution over the entire working space. Spotty and uneven lighting requiring quick adjustment of the eye is the cause of eye fatigue and strain. This is responsible for many errors on the part of employees. These errors are often very costly and in many cases can be eliminated by providing proper lighting conditions.

Proper lighting results cannot always be accomplished in cages of modern banks having high ceilings and fixtures hanging from the ceiling. It is therefore, necessary to provide efficient lighting equipment inside the cages so designed that it will give a strong even light on the work at the same time concealing the light source from the eye of the employee as much as possible. This is the purpose for which the X-Ray bank screen lighting equipment has been designed.

CHARACTERISTICS

X-Ray bank screen lighting equipment produces the maximum amount of light for a given amount of current. It is the most efficient.

X-Ray reflectors are scientifically designed, using pure silver for the reflecting surface. They give a perfect distribution of light on the working plane. The reflectors are designed for the standard 10 and 15 watt lamps. These small lamps produce less heat than the larger sizes and may be purchased for renewal at any electric shop.

The complete equipment is neat, compact, and permanent, no parts to deteriorate, sag or become out of order.

Cleaning of reflectors and renewal of lamps is easily accomplished, as the diffusing glass at the bottom slides, thus exposing the entire interior. The diffusing glass itself is also easily cleaned.

The installation of the section at the cornice of the bank cage is extremely simple, being fastened by screws.

CONSTRUCTION

Heavy gauge metal steel or bronze has been standardized for the material used in manufacturing the housing for the X-Ray bank screen lighting equipment. The standard design of moulding

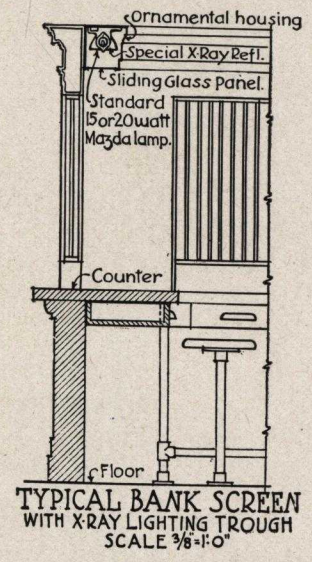


Fig. 460. Cross section of typical bank cage showing correct location of lighting equipment.

GLASS

Many experiments were made with different makes and styles of glass for use at the bottom of the housing, endeavoring to obtain a glass with low absorbing qualities. The ordinary ground or opal glass commonly used for this purpose absorbs from 40% to 60% of the light and a larger percentage after it has been in use and becomes dirty.

The glass adopted for the X-Ray unit is known as prism plate glass. Its upper surface is smooth and highly polished, while the lower surface is broken up by a regular system of small apexes and indentations. This glass gives excellent diffusion shields the light source from view and has an absorption of only about one half that of ordinary ground glass.

REFLECTOR

The X-Ray one-piece silvered glass reflector used in bank screen lighting was designed with special reference to this particular class of work. It was designed for the 10 and 15 watt regular Mazda lamps. The features common to all X-Ray reflectors such as high efficiency, permanency and correct design are incorporated in this new reflector.

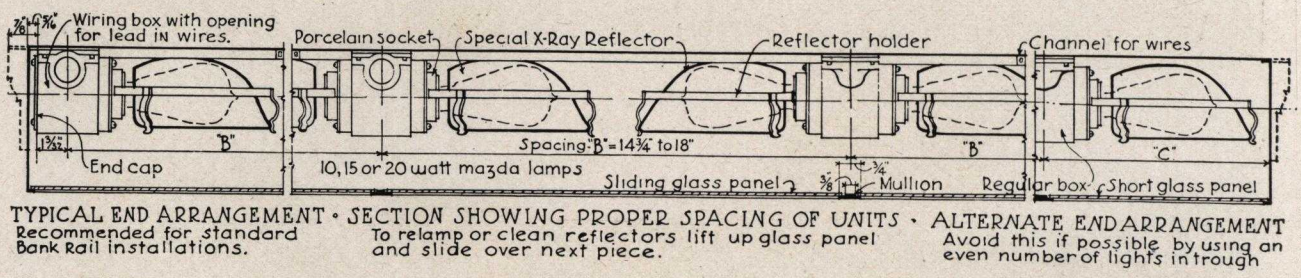


Fig. 461. Cross sectional view of the X-Ray bank desk lighting trough.

for the facing shown in Figure No. 462, is that ordinarily used by architects and harmonizes with the majority of cornice designs. Some bank screens however, are especially designed by the architect and constructed as part of the building. In this case, the complete X-Ray interior equipment including reflector, sockets, wireway and supports may be used in any special moulding of the proper dimensions. The simplicity of construction and comparatively small number of parts makes the installation very simple.

The substantial construction of this Bank Desk Lighting equipment is indicated by the diagram in Fig. 461. The wiring boxes are of cast metal and provide a means of supporting the porcelain receptacles as well as the holders for the specially designed X-Ray reflectors.

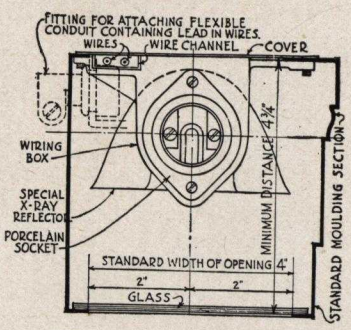
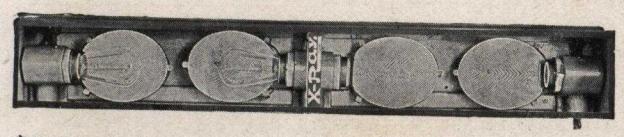


Fig. 462.



BOTTOM VIEW OF FOUR LIGHT SECTION GLASS PANELS REMOVED.

Fig. 463.

TOP VIEW OF FOUR LIGHT SECTION OF X-RAY BANK CAGE LIGHTING TROUGH WITH COVER TAKEN OFF TO SHOW WIRING DETAILS.

Fig. 465.

LAMPS

The regular straight side, clear bulb 10 and 15 watt Mazda lamps are standard for this equipment. Both sizes are made in the same size bulb. It will be readily appreciated that the smaller lamps produce less heat and last longer especially in an enclosed unit of this kind, than those of larger wattage. It is impossible to use larger sizes of lamps than above specified in the X-Ray bank screen lighting equipment.

The spacing of lamps has been standardized and need not enter into the specifications. The spacing of 14¾ inches between centers of outlet boxes has been selected as the most satisfactory minimum spacing. This brings the lamps close enough together to provide uniform illumination over the glass panels, and gives a satisfactory working intensity when using 10 watt lamps. The maximum spacing of outlet boxes is 18 inches.

CURRENT CONSUMPTION

For computing the current consumption for a given section the following table will be of assistance:

If a 10 watt lamp is to be used in a given section the average wattage per foot is 14.5; and for a 15 watt lamp 22.5 watts per running foot.

Watts Per Running Foot for Lamp on Minimum and Maximum Spacing

Size of lamp	Minimum spacing	Maximum spacing	Average
10-watt	16-W. per ft.	13-W. per ft.	14.5-W. per ft.
15-watt	25-W. per ft.	20-W. per ft.	22.5-W. per ft.

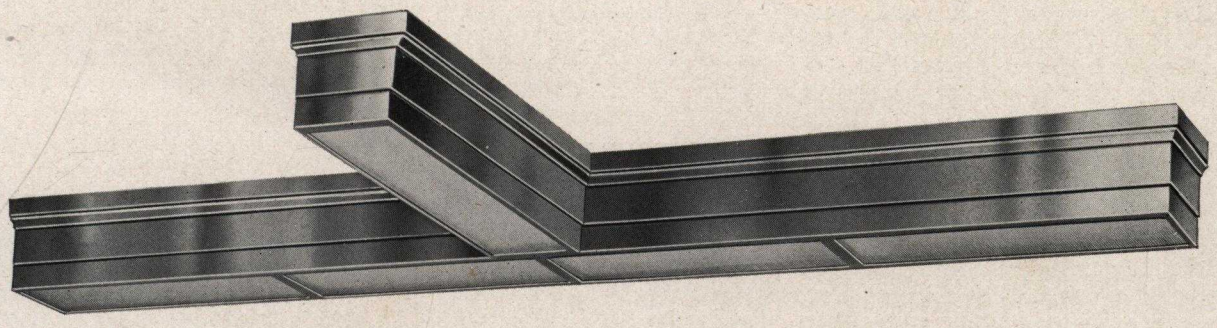


Fig. 464. Exterior view of a section of X-Ray bank screen lighting equipment.

FINISHES

The standard steel housing may be finished in mahogany, oak, olive green or the sprayed washable bronze paint finishes. The genuine bronze moulding obtainable is furnished in natural bronze metal finishes.

WIRING

The wiring is concealed in a shallow channel at the top of the unit. The housing covering also forms a cover for the channel. This channel carries the wires to the cast metal boxes to which the standard X-Ray porcelain sockets are attached. The reflector holder fastens rigidly to the socket. The leading-in wires may enter the housing at the top, back or end as required.

EXPLANATION OF TERMS

Housing.—Bronze or steel moulding and sheet steel which enclose reflectors, holders, sockets, wiring and fittings.

Return End.—Same type of moulding used on end of housing as is used on front side.

Plain End.—Flat sheet steel to close the end in place of carrying moulding around end.

Mitre.—Connecting two sections to form an angle such as in an "L" or "T" section.

Mullion.—Metal strip dividing glass panels.

Length of Section.—Outside overall length.

Front of Section.—With the bank screen lighting unit installed in place in a bank cage, the side nearest the observer inside the cage and facing the section is called the front.

Back.—The back is the side farthest away from the observer when standing in the above position.

Right End.—The end on the right hand of the observer when in the above position.

Left End.—The end on the left hand of the observer when in the above position.

Single Facing.—This applies to the unit made with the ornamental moulding used on the front side only. This is considered standard and will be furnished unless otherwise requested.

Double Facing.—This applies to the unit made with ornamental moulding both on the front and back of the section.

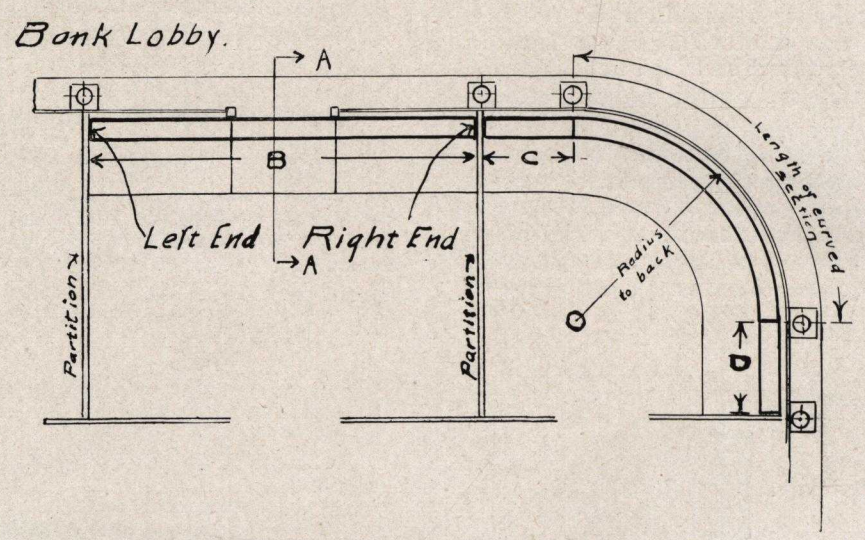


Fig. 466. Plan view of typical bank cage.

The plan of a typical bank cage given above shows the principal dimensions that should be taken into consideration in making measurements for a bank screen lighting equipment. The lengths of straight section are given as B, C, and D. The length of the curved section is the circumference of the outer side or back of the section.

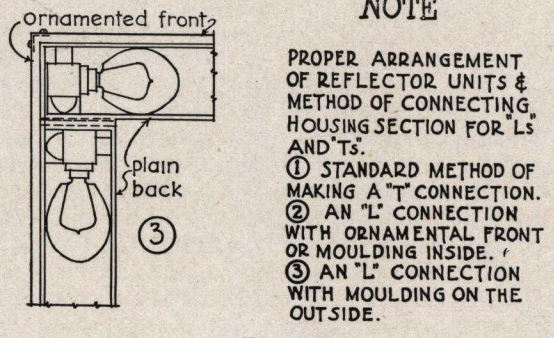


Fig. 467

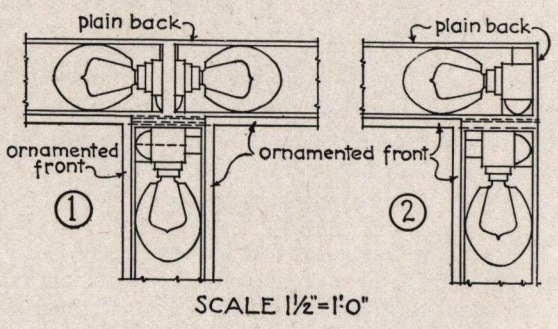


Fig. 468

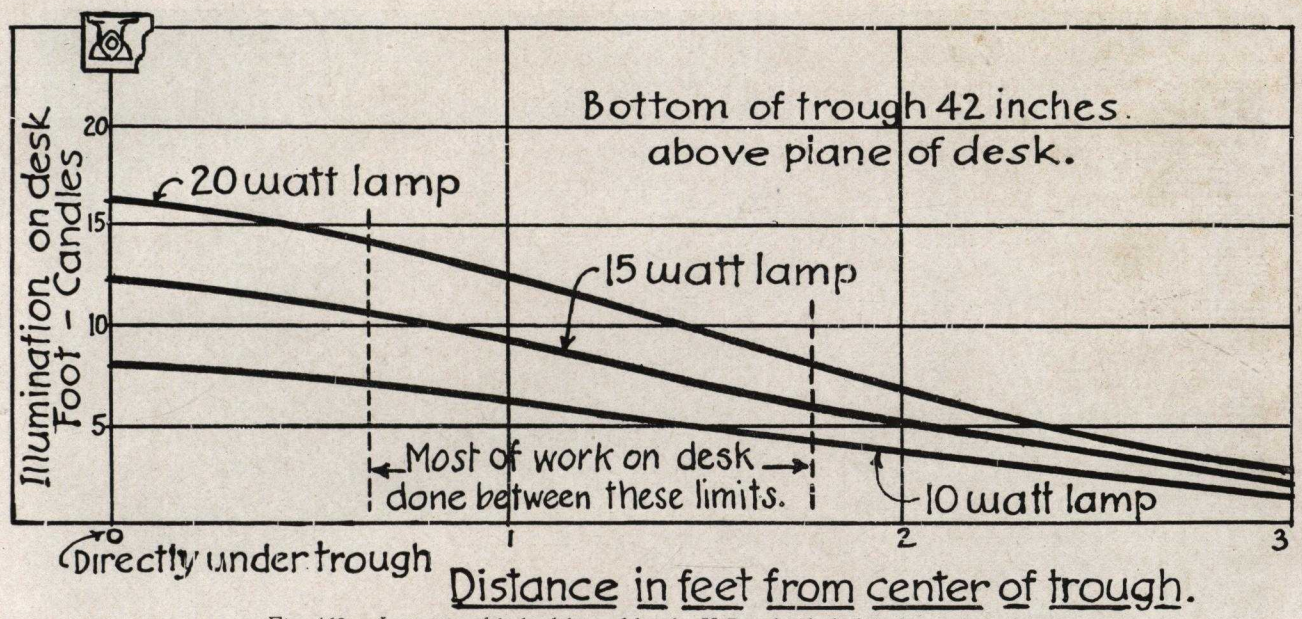


Fig. 469. Intensity of light delivered by the X-Ray bank desk lighting equipment.

LIGHTING RESULTS

By using individual X-Ray reflectors over each lamp and the low absorbing type of diffusing glass, a high intensity of light is secured in a most economical manner. Figure No. 469 shows the intensity of illumination on a desk as secured by using 10 and 15 watt regular Mazda lamps. The illumination was measured by an illuminometer under working conditions with one of the bank screen units. At the position on the desk where the work is done, approximately 5 foot candles intensity is secured from 10 watt lamps. This intensity is ample for close bank cage work and is approximately the same as secured by the use of the 25 watt lamps in less efficient equipment so generally used. Using 10 watt lamps on the minimum spacing, means 16 watts per running foot against 25 watts per running foot in other forms of equipment. By increasing the size of lamps to 15 watts, the intensity is very much increased.

METHOD OF SUPPORTING

The method of supporting this equipment to the bank cage cornice depends largely upon local conditions and the construction of the bank cage cornice. Where possible it will be supported by screws through the back of the housing into the cornice. An angle bracket attached to the top of the housing and cage cornice may also be used where conditions require it. This point will be determined for each particular installation. Details of methods of support are shown below.

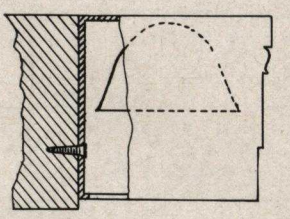


Fig. 470. Support by means of wood screws.

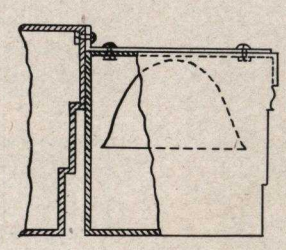


Fig. 471. Support by angle bracket.

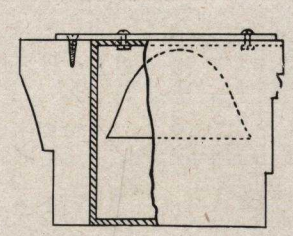


Fig. 472. Support by means of strap.

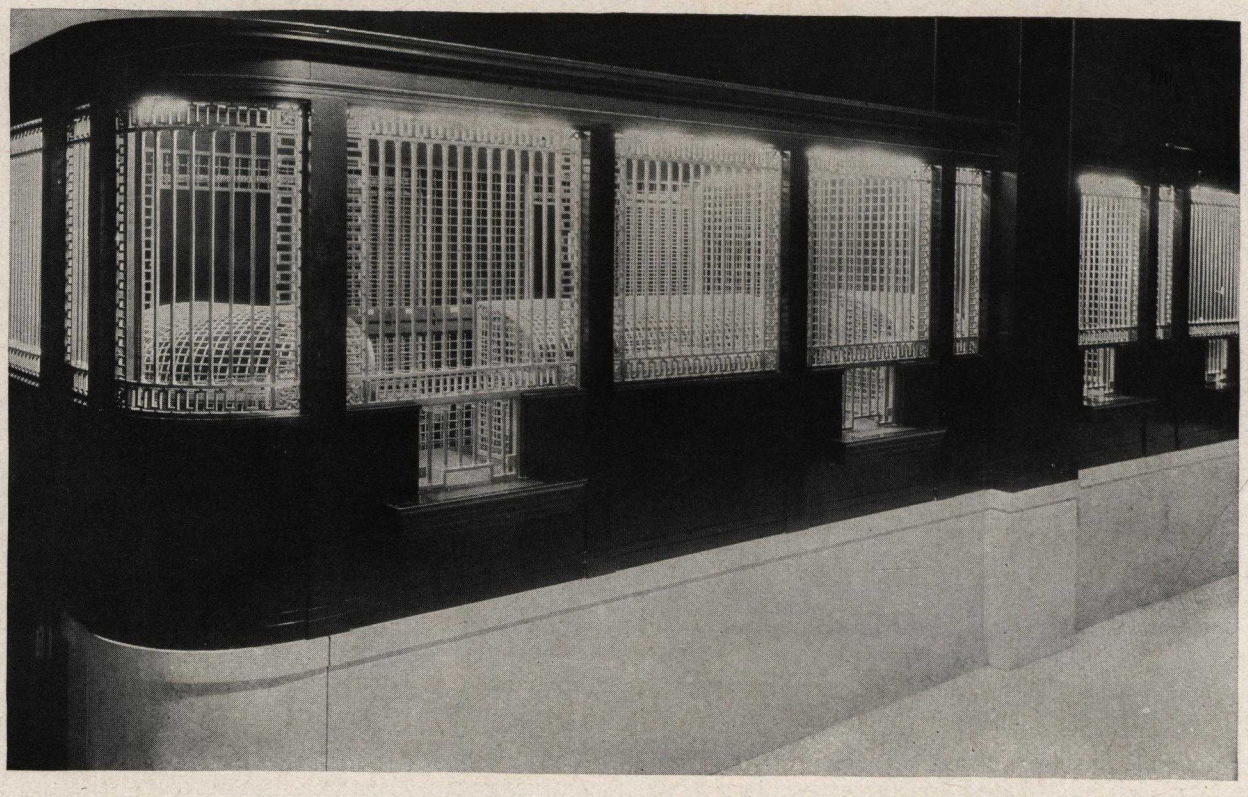


Fig. 473. Exterior view of cashier's cage showing the lighting from the X-Ray bank screen lighting equipment, City Trust & Savings Bank, Dayton, Ohio.

BOOKEEPERS DESK FIXTURES

The mental strain to which bookkeepers are subjected makes it necessary to provide comfortable lighting if maximum mental efficiency is to be obtained. The eyes are constantly engaged on small details and unless protected, they soon tire, thus opening the way for costly errors and embarrassment.

Banks and offices having single or double bookkeepers' desks use continuous local lighting in addition to the diffused overhead system. For this purpose, the X-Ray Bookkeepers' Desk Fixture has been developed employing small lamps and individual reflectors properly housed in an ornamental trough. This housing may be made of steel or bronze. It is three inches high and five and seven-eighths inches wide. The bottom is eighteen inches above the top of the desk. This equipment produces a wide distribution of light at the same time concealing the lamps from the eyes of the workers.

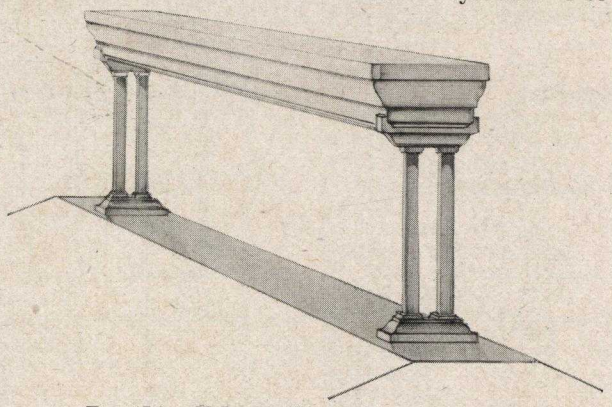


Fig. 474. X-Ray bookkeeper's desk fixture.

Pull Switch Attachment

One of the most satisfactory ways of controlling lamps in bank desk equipment is by means of a pull switch installed inside the section as indicated in the diagram.

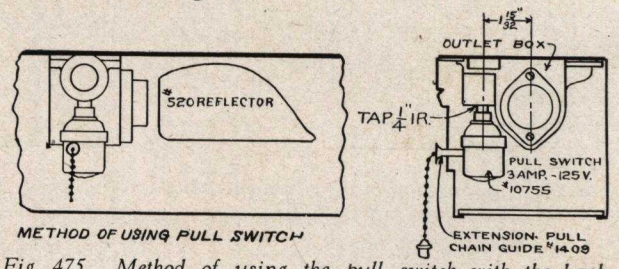


Fig. 475. Method of using the pull switch with the bank desk equipment.

XVII ILLUMINATION DATA

DEFINITION OF THE UNITS, TERMS AND QUANTITIES USED IN ILLUMINATING ENGINEERING WITH THE LAWS GOVERNING THE REFLECTION AND TRANSMISSION OF LIGHT

Acuity—(see Visual Acuity).

Absorption—When light is incident on the surface of a material of any kind, a portion of it is transferred into heat and thus lost as light. The remainder is either reflected or transmitted or portions of it are both reflected and transmitted.

All materials present this power to some extent. Those materials having low absorption receive most favor as reflecting and transmitting mediums.

Ampere—The ampere is the unit of electric current and is defined as the current that will electrolytically deposit silver at the rate of .001118 grams per second. Amperes equal total watts divided by volts.

Apparent Candle-Power—Candle-power at a distance "d" is the candle-power of the simple luminous source which at the distance "d" from the point of observation would give an illumination equal to the observed illumination.

The term should be used only for cases in which the law of inverse squares does not apply. The term is meaningless unless the value "d" is given.

Angle of Incidence—The angle which a ray of light striking a surface makes with the normal to that surface. (See page 19.)

Angle of Reflection—The angle with respect to the normal at which a ray of light leaves a surface after it has been reflected. (See page 19.)

Beam Candle-Power—The beam candle-power produced by searchlights, projectors, or lenses refers to the candle-power in the direction of maximum intensity.

Brightness—The brightness of a surface giving off light is expressed in terms of the *Lambert*.

Bulbs—Lamp bulbs are made in four distinct types: the straight sided, the pear shape, the round or spherical, and the tubular or cylindrical.

Candle-Power—Candle-power is a measure of luminous intensity, a term used to express the intensity of light emanating in any given direction from a light source. It is analogous to steam pressure in steam engineering and voltage or electromotive force in electrical engineering.

Measurement of candle-power is not made directly, but is obtained by comparing with standards of known candle-power, kept in the National Laboratories of France, Great Britain and the United States.

The present unit of candle-power is referred to as the *International Candle*. The following table gives the relation existing between the units in use at the present time:

One International Candle = one American Candle
One International Candle = one French Candle, called *Bougie Decimale*

One International Candle = one English Candle, called *Pentane Candle*

One International Candle = 1.11 German Candle, called *Hefner*

The abbreviation for candle-power is c. p.

Candle-power equals the total watts divided by *watts per candle*. Unless otherwise specified, candle-power and watts per candle refer respectively to the *mean horizontal candle-power* and the *watts per mean horizontal candle-power*.

Candle-Power Rating—In the case of some classes of incandescent lamps, especially those for street series lighting, the sizes are rated in mean horizontal candle-power.

Carbon Lamp—This was the first commercial incandescent lamp, invented and introduced by Thomas A. Edison in 1879. The filament was horseshoe shaped and made of carbonized paper. It had an efficiency of about 7 watts per candle. Later the filament was made of carbonized bamboo and the efficiency raised to about 4.8 watts per candle. The present carbon filament lamps have an efficiency of about 3 watts per candle and a useful life of about 450 hours. The demand for carbon lamps is rapidly decreasing.

Characteristic Curves—A curve which expresses the relation between two variable properties of a luminous source, such as candle-power and volts, candle-power and rate of fuel consumption, etc.

Coefficient of Absorption—This absorption factor is the ratio of the amount of light aborbed by a body to the amount of light incidence upon it. The percentage depends upon the nature of the surface of the medium as well as the color of the light and the *angle of incidence*. (See Absorption.)

Coefficient of Reflection—The ratio of a total luminous flux reflected by a surface to the total luminous flux incidence upon it. In the case of mixed regular, and diffuse reflection the coefficient may be divided into its component parts.

The coefficient of *diffuse reflection* is the ratio of the luminous flux reflected diffusely to the total flux.

The coefficient of *regular reflection* is the ratio of the luminous flux reflected regularly to the total flux.

Coefficient of Transmission—The ratio of the total luminous flux transmitted to the total luminous flux incidence on the surface.

Color—Color is the sensation produced in the eye by reason of the wave lengths or rate of vibration of the light rays. The true color of a body is its daylight color. The apparent color may change when the body is illuminated with light of different colors. The color of different objects is generally due to their ability to absorb certain wave lengths of light and reflect others: for example, a body which absorbs red rays and reflects blue and yellow rays appears green.

C-2 Lamps—(See Mazda C-2 lamps).

Current—The rate of flow of electricity in a conductor. Current is measured in *amperes*.

Diffusion—Light is said to be diffused when by process of *reflection* and *refraction* it reaches the eye from many directions rather than from one direction of the source. It is usually secured by the interposition of opal or frosted globes or by the use of reflectors whose surface is corrugated or dulled. Diffusion is accomplished at some sacrifice in light intensity. The seeing value of the light is improved, however, and glare reduced.

When a light ray strikes a reflecting surface and the reflected light rays are scattered in all directions, the reflection is *diffuse*. A perfectly diffuse surface follows the law,—*The intensity in every direction is proportional to the cosine of the angle of emission measured between the beam of emission and the normal to the surface.*

A rough surface of plaster of paris, the dull surface of dense opal glass and the ordinary dull finish plaster ceiling are very good examples of diffusers.

Diffuse Reflection—Reflectors which give a diffuse reflection include all of the opal or white glass reflectors and all of the porcelain enameled reflectors. These reflectors afford only limited possibilities in the control of light. They may efficiently redirect light, but changes in their shape do not redirect the light in definite directions in desired proportions. It is impossible to make a concentrating reflector of diffusely reflecting surfaces. Such surfaces can only redirect light in a general downward direction. Opal glass reflectors, in addition to reflecting light, transmit light, the quantity of which depends on the density of the glass employed. (See page 20.)

Distribution Curve—A polar diagram showing graphically the distribution of light given out by a source.

Efficiency of Lamps—Lamp efficiency is expressed in terms of the ratio of lumens output to power input. The rated efficiency of Mazda lamps is now preferably expressed in *lumens per watt*, instead of in watt per spherical candle-power or watts per horizontal candle-power. A lamp having a specific output of 20 lumens per watt is twice as efficient as one producing but 10 lumens per watt.

Efficiency of Utilization—The percentage of total lumens emitted by the lamp that reaches the working plane. The value expresses the illuminating efficiency of any given system. In other words, the number of lumens which are effective or usable on the work, or for the lighting of an object, expressed as a per cent of the total lumens delivered by the lamps, is called the efficiency of utilization. This term is entirely independent of the lamp efficiency and is frequently called the net efficiency.

Effective Lumens—The total number of lumens incidence on the working plane. This value may be obtained by multiplying the area of the *working plane* by the average illumination in *foot-candles*.

Effective Lumens per Watt—The effective lumens of a given area divided by the total watts of the lamp illuminating the area is called effective lumens per watt. This term differs from the efficiency of utilization, in that, it takes account of the efficiency of the lamp, and for this reason is often called the gross efficiency.

Flux of Illumination—The flow of radiant energy from a light source. This flux is measured in *lumens*. For a light source the total flux is the total emanation of light from the source. For an area the total flux of illumination is equal to the intensity of the illumination multiplied by the area over which it is distributed.

Foot-Candle—The unit of intensity of illumination It is equal to the illumination falling upon a surface one foot distant from a one candle-power source. If a uniform point source of one candle-power is placed at the center of a sphere of one foot radius, every point on the inner surface of the sphere receives an illumination of one foot-candle. This is apparent from the fact that the area of this unit sphere is 12.57 square feet, and a uniform point source of one candle-power emits 12.57 lumens. Hence, one lumen per square foot gives an average intensity of one foot-candle.

Gem-Lamp—This lamp is an improvement over the carbon filament lamp and employs a "metallized" carbon filament. The Gem lamp operates at about 2.5 watts per candle. The demand for these lamps is at present chiefly in small sizes.

Glare—Glare is a condition of bright light sources or illuminated surfaces which results in ocular discomfort or interference with vision.

Globe—A globe is an enclosing appliance of clear or diffusing material, the chief use of which is either to protect the lamp or diffuse the light.

Hemispherical Candle-Power—(See mean hemispherical candle-power).

Horizontal Candle-Power—(See mean horizontal candle-power).

Horizontal Distribution Curve—A polar curve representing the luminous intensity of a lamp, or lighting unit, in a plane perpendicular to the axis of the unit, and with the unit at the origin.

Hue—Hue is that property of color by which the various spectral regions are characteristically distinguished. All colors except purples and whites may be matched in hue with spectral colors. In the case of a purple, the spectral hue which is complimentary to the hue of purple is ordinarily used for scientific designation.

Incandescent Lamps—The incandescent lamps commonly used for interior illumination are rated in two general voltage classes:

110 to 125 volt,
220 to 250 volt.

Lamps of the first class are in the most common use. They constitute more than 75 per cent of the ordinary lamp demand for such service as residence, store and office lighting.

Incidence—(See angle of incidence).

Intensity—A measure of luminous radiation in any direction without reference to area. *Intensity of light* is measured in candle-power and the *intensity of illumination* in foot-candles.

Intrinsic Brilliancy—A measure of the brightness of light emitting surfaces, expressed in candle-power per square inch, also expressed in lumens per square inch and lumens per square centimeter.

Inverse Square Law—(See law of inverse squares).

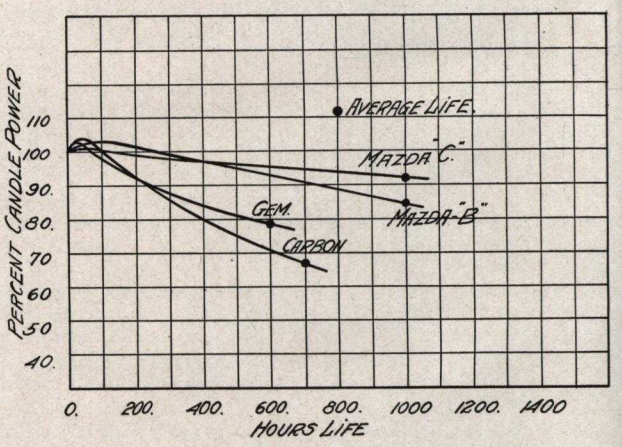


Fig. 476. Curves showing relation of candle power to hours of burning for incandescent lamps. See "Life of Lamps," page 233. (From Railway Electrical Engineers' Handbook. C. W. Bender.)

Illumination—The term illumination is often used to indicate the luminous radiation falling upon a surface in contradistinction to light as luminous radiation emitted from a light source. The *intensity of illumination* is measured in foot-candles and *flux of illumination* of lumens.

Illuminometer—An instrument used for measuring the intensity of illumination. This instrument is sometimes called a portable photometer.

Kilowatt—A Kilowatt is the equivalent of 1,000 watts, a unit of electrical power. One horse-power is equal to 0.746 kilowatt.

Kilowatt-Hour—The kilowatt-hour is the unit of electrical energy and is represented by the expenditure of one kilowatt in one hour. Hence, to obtain the kilowatt hours of any circuit for a given period of time, multiply the kilowatts by the time in hours. The watt hour is 1-1000 part of the kilowatt-hour.

Lambert—The lambert is the unit of brightness. It is the brightness of a perfectly diffusing surface radiating or reflecting one lumen per square centimeter. This is equivalent to a perfectly diffusing surface having a reflection factor equal to unity. For most purposes the *millilambert*, equal to 1-1000 of the lambert, is the preferable practical unit.

A perfectly diffusing surface emitting one lumen per square foot will have a brightness of 1.076 millilambert.

Brightness expressed in candles per square centimeter may be reduced to lamberts by multiplying by 3.14.

Brightness expressed in candles per square inch may be reduced to lamberts by multiplying by 0.487.

Law of Inverse Squares—Unless modified by some interfering agency light rays travel in straight radial lines in all directions from the source. The law of inverse squares follows directly from the fact:

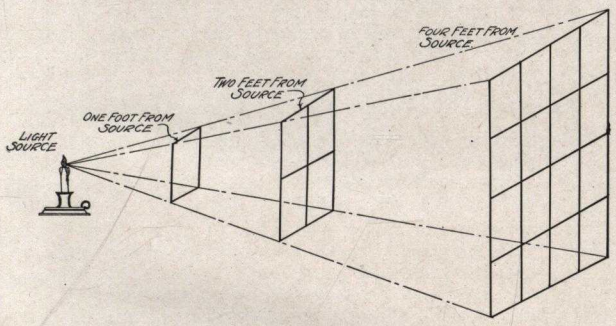


Fig. 477. Diagram illustrating the law of inverse squares.

The intensity of illumination received by a surface from a light source, is directly proportional to the candle-power, and inversely proportional to the source of the distance.

For instance, at one foot from a lamp giving 16 candle-power the intensity would be 16 foot-candles; at 2 feet, 4 foot-candles, and at 4 feet, one foot-candle. See Fig. 477.

Life of Lamps—The total life of a lamp is the period of time that it will operate before it "burns out."

The useful life of an incandescent lamp is given as the number of hours which this lamp will burn before its candle-power is reduced 20 per cent. See Fig. 476.

Light Distribution Curves—The intensity of light in candle-power from a source is indicated by a light distribution curve. The intensities corresponding to various angles of emission, about either the horizontal or vertical axis, are plotted in polar co-ordinants. Figure 478 shows a distribution curve of an incandescent lamp in a vertical plane. (See Distribution Curve.)

Lumen—The lumen is the unit of flux of light or illumination. The flux required to light a given surface is proportional to the illumination and the area of the surface. One lumen will light a surface of one square foot to an average of one foot-candle intensity. The number of lumens required to light a surface to any given illumination is equal to the product obtained by multiplying the area of the surface in square feet by the average foot-candles which it is desired to produce. For a light source the total number of lumens delivered equals the mean spherical candle-power multiplied by 12.57.

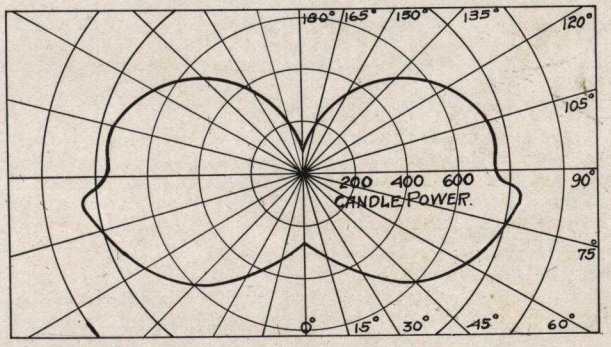


Fig. 478. The distribution curve of a 500-watt Mazda "C" Lamp. See "Light distribution curve" below.

Lumens Effective—(See Effective Lumens).

Lumen-Hours—The lumen-hour is the unit of luminous energy, and is defined as the quantity of luminous energy which would be emitted in one hour from a unit having a total luminous flux of one lumen.

Hence, the total lumen-hours for any light source operating a given length of time is equal to the total lumens of the source multiplied by the time in hours.

Lumens per Watt—The efficiency of an incandescent lamp may also be expressed as lumens per watt. Lumens per watt equals lumens divided by watts. Effective lumens per watt is a measure of the efficiency of a lighting installation and equals the total effective lumens divided by the total watts input of all units, equals mean foot-candles divided by watts per square foot.

Luminous Efficiency—The luminous efficiency of any light source is the ratio of the luminous flux to the radiant flux from the source and is expressed in *lumens per watt.*

Luminous Intensity—The intensity with which light flux is emitted in any certain direction.

Luminosity—A term which expresses the brightness of a surface from which light arises as the result of either diffusion or emission.

The luminosity of the diffusely reflecting medium is expressed as the illumination of the body multiplied by the reflection coefficient, likewise the luminosity of a diffusely transmitting surface, such as dense opalescent glass, is the illumination incident on the surface multiplied by the coefficient of transmission.

Lux—A unit of illumination. The intensity produced by one candle-power at a distance of one meter. It is equal to one meter-candle of one lumen per square meter.

Mazda B Lamps—A Mazda lamp is a tungsten lamp. The filament of the Mazda B lamps operates in a vacuum.

Mazda C Lamps—These lamps have the bulb filled with inert gas and are usually made in bulbs with long necks.

Mazda C-2 Lamps—This lamp is designed to produce light of a quality which will ordinarily make colors appear

as in the light of day. The bulbs of these lamps are made of a special blue glass to filter out the excess red and yellow light rays and for this reason are called Mazda C-2 lamps to distinguish them from the clear bulb Mazda C lamp. They are made in sizes from 75 to 500 watts.

Mean Hemispherical Candle-Power—The average of the intensities of a given light source in all directions of the lower hemisphere or upper hemisphere as the case may be.

Mean Horizontal Candle-Power—The average of all of the candle-power values lying in a horizontal plane passing through the luminous center of the lamp.

The mean horizontal candle-power cannot satisfactorily be used to indicate the light output of other than vacuum incandescent lamps and lamps without concentrated filament. Because of this limitation it is being superseded by ratings dependent directly upon the total light emitted.

Mean Spherical Candle-Power—The average candle-power of a lamp in all directions in space. The mean spherical candle-power bears a definite relation to the total flux of light from the lamp, and is, therefore, sometimes used as a measure of that quantity.

Millilambert—Is 1-1000 part of a lambert. (See lambert.)

Normal Brightness—The normal brightness of an element of a surface is the brightness taken in a direction normal to the surface. Normal brightness is sometimes called the specific luminous intensity.

Ohm—The unit of resistance is the ohm. It is defined as the resistance of a column of mercury one square millimeter in cross sectional area and 106 centimeters in length.

Opalescent—The property of certain kinds of glass which renders it a diffuser of light by reason of its containing small white particles which reflect the rays of light as they pass through.

Performance Curves—The performance of lamps or a class of lamps is the information as to their operation under different conditions. The information is usually put in the form of curves showing the variation of voltage, current, resistance, power consumption, efficiency, and life, with candle-power all expressed in percentage of normal efficiency values.

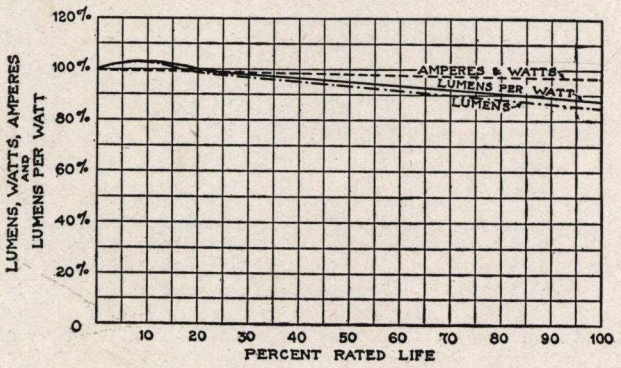


Fig. 479. Performance curves for multiple Mazda "B" incandescent lamps. From Lamp Data Book of National Lamp Works, Cleveland, Ohio.

Photometer—A photometer is a device used to compare the candle-power of different light sources.

Photometric Curves—(See Distribution Curves).

Potential—(See voltage).

Power—The rate of doing work or the rate of dissipating energy. The units of power are the horse-power and the watt.

Reduction Factor—The reduction factor of a light source is the ratio of the mean spherical candle-power to the mean horizontal candle-power. It is usually less than unity and is commonly expressed as a percentage or as a decimal. It is seen from the definition that the mean spherical candle-power can be obtained by multiplying the mean horizontal candle-power by the reduction factor.

Reflector—Appliance or lamp accessory designed to accomplish a twofold purpose. It redirects the light flux from the lamp so that it may be utilized most efficiently and conceals the lamp so that the eye is protected from the intense brilliancy of the tungsten filament of the lamp.

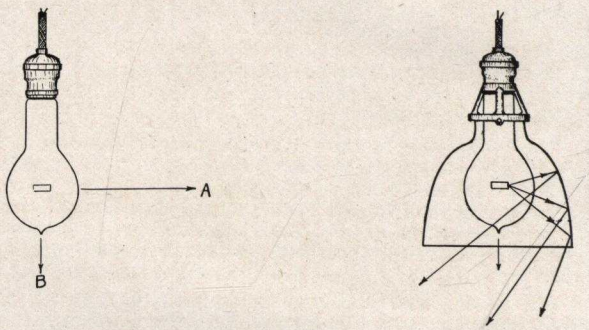


Fig. 480. Diagram illustrating how a reflector catches up the light from lamp and re-directs it at useful angles.

Refraction—When rays of light pass through a plate of clear glass, refraction occurs. The ray undergoes a change in direction, the magnitude of which depends on the relative densities of the medium through which the ray passes and the surrounding air. When the ray leaves the medium it again changes its direction.

Reflection—Reflection occurs when rays of light are projected upon a surface and are thrown back from it. Light is reflected in three ways: *regularly*, *diffusely*, and by *spread reflection*. (See page 19.)

Reflection Coefficient—(See Coefficient of Reflection).

Regular Reflection—Regular or specular reflection occurs when a beam of light falls upon a highly polished surface. The familiar law, the angle of incidence is equal to the angle of reflection, applies to this type of reflection.

Reflectors which follow the law of regular reflection include those having mirrored and polished metal surfaces. These afford a high degree of light control. The surfaces of the reflectors may be shaped so as to produce high concentration, a wide distribution, non-symmetrical distribution, etc., without any difficulty. In fact, if the commercial lamps were point sources these reflectors would have practically perfect light control. (See page 19.)

Resistance—Resistance is the property of an electrical circuit which opposes the flow of a current through the conductor. The *ohm* is the unit of resistance.

Saturation of Color—The degree of freedom from admixture with white. As white light is added to a colored light the saturation decreases until when the hue entirely disappears the saturation is zero. White, therefore, is the limiting color having no hue and zero saturation.

Selective Radiation and Reflection—Some materials transmit and reflect light selectively, that is, they transmit a predominant of some particular color. Thus, a green glass transmits mostly green light and largely absorbs the other colors. A red glass transmits mostly red light. Polished gold reflects chiefly yellow light, etc.

Shade—An appliance, the chief use of which is to diminish or interrupt the flux of light from the lamp in certain

directions where this flux is not desirable. The function of the shade is commonly combined with that of the reflector. Reflectors are often erroneously called shades.

Spectrum—Daylight and artificial light may be broken up into their various component parts or colors by means of a prism. The arrangement of colors produced by this analysis is called the spectrum. The principal colors of the spectrum are violet, blue, green, yellow, orange, and red.

Specular Reflection—(See Regular Reflection).

Spherical Candle-Power—(See Mean Spherical Candle-Power).

Spherical Reduction Factor—(See Reduction Factor)

Spread Reflection—The term spread reflection is s ome times used to designate specular reflection having a diffuse component such as is obtained from an aluminum surface. There is a breaking up of the beam, but with a certain direction to the scattered rays.

Reflectors which follow the law of spread reflection include satin finish prismatic reflectors, aluminized metal reflectors, and satin finish or depolished mirror reflectors. Such surfaces occupy a position about midway between the specular and diffuse reflecting media. They afford a greater degree of light control than diffuse reflectors, but a lesser degree than specular reflectors. (See page 19.)

Tantalum Lamp—This lamp which was placed on the market in 1906 provided a higher efficiency than the Gem lamp. It operated at about 2 watts per candle. The demand for this lamp has practically disappeared. It has given way to the tungsten lamp.

Transmission—Transmission may be defined as the passage of light through a medium.

Tungsten Lamp—The most efficient form of incandescent lamps. The filament of this lamp is made of metal tungsten. The average efficiency of the lamp is about one watt per candle.

Utilization Factor—(See Efficiency of Utilization).

Vertical Distribution Curves—A polar curve representing the luminous intensity of a lamp or lighting unit in a plane passing through the axis of the unit and with the unit at the origin. In the case of incandescent lamps it is assumed that the vertical distribution curve is taken with the tip downward.

Visible Spectrum—That portion of the spectrum which is visible, that is, capable of producing a sensation in the eye.

Visual Acuity—The ability of the eye to distinguish fine detail in contradistinction to the seeing of ordinary objects which are observed by differences in light and shade. Visual acuity, for example, is the measure of ability to read type, etc., but has little to do with the seeing of persons, buildings, or other ordinary objects.

Volt—The volt is the unit of the electro-motive force. and is defined as an electro-motive force of such magnitude as to cause a current of one ampere to flow through a conductor having a resistance of one ohm. Volts equal total watts divided by amperes.

Voltage—Electrical pressure measured in volts.

Watt—The watt is the unit of electric power and is represented by a current of one ampere under an electro-motive force of one volt. Volts multiplied by amperes gives watts.

Watt-Hour—The unit of electrical energy, the amount of energy consumed when one watt of power is maintained for one hour. It is the product of power and time.

Watts per Candle-Power—Indicates the amount of electrical power necessary to produce unit luminous intensity. The efficiency of an incandescent lamp is usually expressed as watts per mean horizontal candle-power or mean spherical candle-power, ordinarily called *watts per candle*.

Watts per Square Foot—The total watts of the lamp illuminating an area divided by that area in square feet, is the watts per square foot.

Working Plane—The working plane or plan of reference is the plane on which the work is performed and which, therefore, must be adequately and satisfactorily illuminated.

Wattage Rating—Lamp sizes for interior illumination are now most commonly given in the watts consumed when operated at their rated voltage.

STANDARD SYMBOLS FOR WIRING PLANS

AS ADOPTED AND RECOMMENDED BY

THE NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION OF THE UNITED STATES and THE AMERICAN INSTITUTE OF ARCHITECTS,

Copies may be had on application to the Sec'y of The Nat. Elec. Cont. Associ'n, Utica, N. Y., and the Sec'y of The American Instit. of Architects, Washington, D. C.

- (4) Ceiling Outlet; Electric only. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.
- 4/2 Ceiling Outlet; Combination. 4/2 indicates 4-16 C. P. Standard Incandescent Lamps and 2 Gas Burners. If gas only
- (2) Bracket Outlet; Electric only. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.
- 4/2 Bracket Outlet; Combination. 4/2 indicates 4-16 C. P. Standard Incandescent Lamps and 2 Gas Burners. If gas only
- 2 Wall or Baseboard Receptacle Outlet. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.
- 4 Floor Outlet. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.
- 6 Outlet for Outdoor Standard or Pedestal; Electric only. Numeral indicates number of Stand. 16 C. P. Lamps.
- 6/6 Outlet for Outdoor Standard or Pedestal; Combination. 6/6 indicates 6-16 C. P. Stand. Incan. Lamps; 6 Gas Burners.
- D Drop Cord Outlet.
- One Light Outlet, for Lamp Receptacle.
- Arc Lamp Outlet.
- Special Outlet, for Lighting, Heating and Power Current, as described in Specifications.
- Ceiling Fan Outlet.
- S^1 S. P. Switch Outlet.
- S^2 D. P. Switch Outlet.
- S^3 3-Way Switch Outlet.
- S^4 4-Way Switch Outlet.
- S^D Automatic Door Switch Outlet.
- S^E Electrolier Switch Outlet.

Show as many Symbols as there are Switches. Or in case of a very large group of Switches, indicate number of Switches by a Roman numeral, thus: S^1 XII, meaning 12 Single Pole Switches.

Describe Type of Switch in Specifications, that is, Flush or Surface, Push Button or Snap,

- Meter Outlet.
- Distribution Panel.
- Junction or Pull Box.
- (S) Motor Outlet; Numeral in center indicates Horse Power.
- Motor Control Outlet.
- Transformer.

- Main or Feeder run concealed under Floor.
- Main or Feeder run concealed under Floor above.
- Main or Feeder run exposed.
- Branch Circuit run concealed under Floor.
- Branch Circuit run concealed under Floor above.
- Branch Circuit run exposed.
- Pole Line.
- Riser.

- Telephone Outlet; Private Service.
- Telephone Outlet; Public Service.
- Bell Outlet.
- Buzzer Outlet.
- 2 Push Button Outlet; Numeral indicates number of Pushes.
- (8) Annunciator; Numeral indicates number of Points.
- Speaking Tube.
- (C) Watchman Clock Outlet.
- Watchman Station Outlet.
- (TC) Master Time Clock Outlet.
- Secondary Time Clock Outlet
- Door Opener.
- Special Outlet; for Signal Systems, as described in Specifications.
- Battery Outlet.

- Circuit for Clock, Telephone, Bell or other Service, run under Floor, concealed.
  Kind of Service wanted ascertained by Symbol to which line connects.
- Circuit for Clock, Telephone, Bell or other Service, run under Floor above, concealed.
  Kind of Service wanted ascertained by Symbol to which line connects.

NOTE—If other than Standard 16 C. P. Incandescent lamps are desired, Specifications should describe capacity of Lamp to be used.

SUGGESTIONS IN CONNECTION WITH STANDARD SYMBOLS FOR WIRING PLANS

It is important that ample space be allowed for the installation of mains, feeders, branches and distribution panels.

It is desirable that a key to the symbols used accompany all plans.

If mains, feeders, branches and distribution panels are shown on the plans, it is desirable that they be designated by letters or numbers.

Heights of Centre of Wall Outlets (unless otherwise specified)

Living Rooms	5′ 6″
Chambers	5′ 0″
Offices	6′ 0″
Corridors	6′ 3″

Height of Switches (unless otherwise specified) 4′ 0″

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XVIII MISCELLANEOUS DATA

REFLECTION AND ABSORPTION TABLES—WIRING SYMBOLS, ETC.

ABSORPTION OF GLASS

The table below gives the percentage of light absorbed by various kinds of glass. This table is especially useful in figuring on jobs in which the lighting through skylights is involved.

No.	Glass	Percent Absorption
1	Pat. Blue	98.4
2	Light Gray	57.4
3	Medium Gray	88.9
4	Euphar Green	25.8
5	Pat. Green	85.8
6	Pat. Yellow	71.2
7	Fl. Yellow	36.1
8	Pat. Purple	88.7
9	Fl. Ruby	94.0
10	Fl. Purple	87.6
11	Cathedral 300 L. L.	22.8
12	Equalite	63.1
13	Opalescent 139 G.	48.8
14	Opalescent No. 6	22.8
15	Alba-Illia	37.0
16	Illuminal	31.8
17	Deflex No. 1	20.0
18	Alba Sheet Glass	21.9

Glass mentioned in the above table is manufactured by Leo. Popper & Sons, New York City.

REFLECTION COEFFICIENTS*

Surface	Percent
White blotting paper	82
White cartridge paper	80
Ordinary foolscap	70
Ordinary newspaper	50 to 70
Chrome yellow paper	62
Orange paper	50
Plain boards (clean)	45
Yellow wall paper	40
Yellow painted wall (clean)	40
Light pink paper	36
Tracing cloth	35
Blue paper	25
Tracing paper	22
Plain boards (dirty)	20
Yellow painted wall (dirty)	20
Emerald green	18
Dark brown paper	13
Vermilion paper	12
Blue green paper	12
Cobalt blue paper	12
French ultramarine blue paper	3.5
Black cloth	1.2
Black paper	0.5
Deep chocolate paper	0.4
Black velvet	0.4

*From Railway Electrical Engineers Handbook—C. W. Bender.

REFLECTING POWER OF PAINTED SURFACES*

Color of Painted Surface	Coefficient of Reflecton. Percent
Light cream	66
Light Pink	60
Light yellow	58
Light blue	55
Light greenish yellow	54
Light buff	52
Light green	42
Light terra cotta	41
Medium terra cotta	39
Light greenish blue	36
Medium blue	32
S. green	19
Medium green	14
Red	12
S. Blue	12
Green	11

*George B. Heckel, in *Textile World Journal* June, 1917.

ABSORPTION COEFFICIENTS*

Kind of Glass	Percent
Clear glass globes absorb from	5 to 12
Light sand blasted globes absorb from	10 to 20
Alabaster globes absorb from	10 to 20
Canary-colored globes absorb from	15 to 20
Light blue alabaster globes absorb from	15 to 25
Heavy blue alabaster globes absorb from	15 to 30
Ribbed glass globes absorb from	15 to 30
Opaline glass globes absorb from	15 to 40
Ground glass absorbs from	20 to 30
Medium opalescent globes absorb from	25 to 40
Heavy opalescent globes absorb from	30 to 60
Flame glass globes absorb from	30 to 60
Signal green globes absorb from	80 to 90
Ruby glass globes absorb from	85 to 90
Cobalt blue globes absorb from	90 to 95

*From Railway Electrical Engineers Handbook—C. W. Bender.

LIGHT ABSORBED BY DIFFERENT STYLES OF FROSTING*

	Bowl Frosted	All Frosted	All Frosted Lamps in Reflector
Decrease in mean lower hemispherical candlepower	6.0%	9.5%	11.5%
Decrease in mean spherical candlepower	4.5%	8.0%	7.5%

*From *Incandescent Lamp Illumination*—Edison Lamp Works.

INTRINSIC BRILLIANCIES OF VARIOUS ILLUMINANTS*

	Barrows Candle-power per Sq. In.	Ives and Luckiesh Candle-power per Sq. In.	Candle-power per Sq. mm.
Sun at zenith	600,000	.....	.....
Crater, carbon arc	200,000	84,000	130.
Open carbon arc	10,000-50,000	.....	.....
Flaming arc	5,000	.....	.....
Magnetite arc	.....	4,000	6.2
Nernst glower	800-1,000	.....	.....
Nernst glower (115 volts, 6 amp., d. c.)	.....	3,010	4.7
Incandescent lamps:			
MAZDA, 1.25 w. p. c.	1,000	1,060	1.64
MAZDA, 0.6 w. p. c.	.....	3,400	.....
Graphitized carbon filament, 2.5 w. p. c.	625	750	1.2
Tantalum, 2.0 w. p. c.	750	580	0.9
Carbon, 3.1 w. p. c.	480	485	0.75
Carbon, 3.5 w. p. c.	375	400	0.63
Carbon, 4.0 w. p. c.	300	325	0.50
Inclosed carbon arc (d. c.)	100-500	.....	.....
Acetylene flame	75-100	.....	.....
Acetylene flame (1-ft. burner)	.....	53.0	0.082
Welsbach mantle	20-25	31.0	0.048
Welsbach (mesh)	.....	56.0	0.067
Cooper-Hewit mercury-vapor lamp	16.7	14.9	0.023
Kerosene flame	4-8	.9	0.014
Candle flame	3-4	.....	.....
Gas flame (fishtail)	3-8	2.7	0.004
Frosted incandescent lamp	4-8	.....	.....
25-watt frosted MAZDA lamp:			
Tip	.....	1.67	0.0026
Side	.....	6.00	0.0093
Moore carbon dioxide tube lamp	0.6	.....	.....

#From Railway Electrical Engineers Handbook - C.W. Bender

EFFECT OF COLORED LIGHTS ON VARIOUS COLORS*

Color of light falling upon fabrics

Original Color of Fabric	Red	Orange	Yellow	Green	Blue	Violet
Black	Purplish-Black	Deep Maroon	Yellow-Olive	Greenish Brown	Blue Black	Faint Violet Black
White	Red	Orange	Light Yellow	Green	Blue	Violet
Red	Intense Red	Scarlet	Orange	Brown	Violet	Red-Violet Purple
Orange	Orange Red	Intense Orange	Yellow Orange	Faint Yellow, slightly Greenish	Brown slightly Violet	Light Red
Yellow	Orange	Yellow-Orange	Orange-Yellow	Yellow-ish Green	Green	Brown tinged with Faint Red
Light Green	Reddish Gray	Yellow-Green	Greenish Yellow	Intenser Green	Blue-Green	Light Purple
Deep Green	Reddish Black	Rusty Green	Yellow-ish Green	Intenser Green	Greenish Blue	
Light Blue	Violet	Orange-Gray	Yellow-ish Green	Green-Blue	Vivid Blue	
Deep Blue		Gray slightly on Orange	Green-Slate	Blue-Green	Intenser Blue	Bright Blue-Violet
Indigo Blue		Orange-Maroon	Orange-Yellow (very dull)	Dull Green	Dark Blue Indigo	Deep Blue Violet
Violet	Purple	Red Maroon	Yellow-Maroon	Bluish Green-Brown	Deep Bluish Violet	Deep Violet

*Dr. Bell: "Art of Illumination."

CARRYING CAPACITES OF WIRES

Allowable by National Board of Fire Underwriters

B. & S. Gauge Number	Diameter of Solid Wire in Mils.	Area in Circular Mils.	Rubber Insulation Amperes	Other Insulation Amperes
18	40.3	1,624	3	5
16	50.8	2,583	6	10
14	64.1	4,017	15	20
12	80.8	6,530	20	25
10	101.9	10,380	25	30
8	128.5	16,510	35	50
6	162.0	26,250	50	70
5	181.9	33,100	55	80
4	204.3	41,740	70	90
3	229.4	52,630	80	100
2	257.6	66,370	90	125
1	289.3	83,690	100	150
0	325.	105,500	125	200
00	364.8	133,100	150	225
0000	409.6	167,800	175	275
		200,000	200	300
0000	460.	211,600	225	325

COLOR OF ILLUMINANTS*

Source	Sensation Values Red	Green	blue
1. Black body 5000 degrees abs	33.3	33.3	33.3
2. Blue sky (S)	26.8	27.2	46.0
Blue sky (C)	32.0	32.0	35.8
3. Overcast sky	34.6	33.9	31.5
4. Afternoon sun	37.7	37.3	25.0
5. Hefner lamp	54.3	39.5	6.2
6. Carbon Incandescent lamp, 3.1 w. p. m. h. c	51.1	40.5	5.4
7. Acetylene	48.6	40.8	10.6
8. MAZDA incandescent lamp, 1.25 w. p. m. h. c	48.3	40.8	10.9
9. Nernst	49.2	40.7	11.1
10. Welsbach, ¼% cerium	42.5	40.8	16.7
11. Welsbach, ¾% cerium	45.4	42.0	12.6
12. Welsbach, 1¼% cerium	47.2	41.8	11.0
13. D. C. Arc	41.0	36.3	22.7
14. Mercury arc	29.0	30.3	40.7
15. Yellow flame arc	52.0	37.5	10.5
16. Moore carbon-dioxide tube	31.3	31.0	37.7

*From "Color and its Applications"—*Luckiesh.*

TABLES OF COSINES CUBED

The table below gives for various angles the values of the cosine cubed. These values, when used in connection with the formula, given on page 125 for the point-by-point method, make it possible to determine the illumination from a lighting unit at any position in an interior. The angle designated is the angle between the director of the ray of light under consideration and the perpendicular line passing through the axis of the lamp.

Angle Degrees	Cosine Cubed	Angle Degrees	Cosine Cubed	Angle Degrees	Cosine Cubed
1	1.000	31	.630	61	.114
2	.998	32	.610	62	.103
3	.995	33	.590	63	.0936
4	.993	34	.570	64	.0842
5	.988	35	.550	65	.0754
6	.983	36	.529	66	.0671
7	.978	37	.509	67	.0596
8	.971	38	.489	68	.0526
9	.963	39	.469	69	.0460
10	.955	40	.449	70	.0400
11	.945	41	.429	71	.0345
12	.935	42	.410	72	.0295
13	.925	43	.391	73	.0250
14	.913	44	.372	74	.0209
15	.901	45	.353	75	.0173
16	.888	46	.335	76	.0142
17	.874	47	.317	77	.0114
18	.860	48	.300	78	.00900
19	.845	49	.282	79	.00695
20	.829	50	.265	80	.00523
21	.813	51	.249	81	.00383
22	.797	52	.233	82	.00270
23	.780	53	.218	83	.00181
24	.762	54	.203	84	.00114
25	**.744**	55	.189		
26	.726	56	.175		
27	.707	57	.161		
28	.688	58	.149		
29	.668	59	.137		
30	.649	60	.125		

INDEX

[*The references are to page numbers. For analytical outline see "Contents"—page 9*]

Absorption
  coefficients,-237
  of glass,-237
  of skylight glass,-147
Accidents, industrial,-117
Adapter for Curtis indirect portable lamp,-105
Adding machine lighting,-191
Amusements, flood lighted,-219
Applications of flood lighting,-207
Applications of X-Ray indirect lighting,-39
Arcade lighting,-170
Arcade show window,-170
Armories,-139, 152
Art museum,-145, 154
Assembly department,-131
Assembly halls,-63
Athletic grounds, flood lighted,-219
Atrium of public building,-145
Auditorium
  of church,-59, 158
  of theatre,-64
  tabernacle,-150
  theatre, cove lighting,-107
  theatre, lighted from wall boxes,-109
Auditoriums,-63
  cove lighting,-90
Automobile show room, lighted from column clusters,-108

Back entrance method for Scoopettes,-184
Backgrounds, show windows,-163
Balcony floor, lighted from pedestals,-94
Ball room,-51
Band platform, armory,-139
Bank cage, local lighting with Brackette,-189
Bank cove lighting,-112
Bank desk equipment,-225
  construction of,-226
  descriptive terms,-228
  finishes,-227
  glass used with,-226
  lamps for,-227
  lighting results from,-229
  methods of supporting,-229
  pull switch attachment,-230
  reflectors for,-226
  sectional view,-226
  wattage consumed,-227
  wiring of,-227
Bank desk lighting,-225
Bank,
  flood lighted,-207
  lighting without ceiling fixtures,-92
  partition lighting,-92
Banking room, lighted by column clusters,-97
Banks,-44
Baptistry, lighted by indirect brackets,-98
Barber shop,-49
Bath room, residence,-77
Bed room,-76
Bench lighting,-136
Best light for the eyes,-21
Billiard rooms,-51
Billiard table,-142
Blackboard,-151
Bookkeepers' desk fixture,-230
Bookrack lighting with Scoopette,-188
Bookstacks,
  in library,-98
  lighting of,-55
Bowling alleys,-142
Brackets, for indirect lighting,-98, 99
Brackette,-189
Bridge, flood lighted,-217
Bright lighting in auditoriums,-63, 65
Brilliancy, intrinsic, of various illuminants,-238
Bulletins, flood lighted,-212

Cafe,-66
Cafe color lighting,-149
Cafeteria,-67
Calculations,
  for direct lighting,-121
  for flood lighting,-204
  for indirect lighting,-33, 36, 37
  short cut method for indirect lighting,-36, 37
Candelabra brackets,-99
Candy shop lighted with indirect portable lamp,-104
Capitol Building, flood lighted,-193
Carpet display rack,-151
Cashier's cage,-225
Catalogue room, libraries,-54
Cathedral, lighted without hanging fixtures,-113
Ceiling,
  color of, for indirect lighting,-33
  light reflected from,-29
  secondary light source,-29
Chemical laboratories,-54
Children's room, hospital,-71
Chimneys, flood lighted,-213
Church,-86
  auditoriums, cove lighting,-90
  baptistry,-98
  direct lighting in,-158
  fixtures for Gothic,-61
Church lighting,-85
  with single fixtures,-60
  without fixtures,-113
Churches,-59
City Hall, atrium,-145
Class rooms,-54
Cleaning
  indirect lighting fixtures,-78
  of reflectors,-118
Club,
  dining room,-66
  lounge,-81
  solarium, lighted from floor pedestal,-110
  tennis courts,-150
Clubs,-50, 51
Coefficients
  of absorption,-237
  of reflection,-237
College, gymnasium,-159
Colleges,-53
Color lighting
  effects in theatres,-65
  in cafe,-149
  in dining room,-82
Color of ceilings for indirect lighting,-33
Colors, effect of colored lights on,-238
Column caps, lighting Cathedral from,-113

Column clusters,
auto show rooms,-108
for indirect lighting,-96, 97
Composing room, printing plant,-137
Congressional library,-55
bookrack lighting,-188
Construction work at night, flood lighting,-221
Control of light,-19
Control of lighting units,-138
Corridor, in library,-98
Corridors, hospital,-71
Cosines, cubed, table of,-239
Counter lighting unit for jewelry cases,-47
Country club, ball room,-51
Court room,-73
Court, squash racket,-143
Court, tennis,-150
Cove lighting,-90
in arcade,-171
in bank,-112
in conference room,-91
in entrance,-91
in lobby,-91
in show windows,-175
in theatre auditoriums,-107
Cutting department,-131
Curtis Portable,
adaptability to lamp standards,-103
adapter,-105
in the home,-102
lamp,-101
uses for,-104

Data
miscellaneous,-237
on illumination,-231
Daylight, indirect lighting almost equal to,-26
Deck, show windows,-172
Definitions of lighting terms,-231
Department stores,-45, 46
Desk fixture for bookkeepers,-230
Desk lighting,-189
bank cages,-225
Deskette,-189
Diet kitchens, hospitals,-70
Diffuse reflection,-19
Diffused lighting for show window,-176
Diffuser, reflector,-23
Dim lighting in auditoriums,-63, 65
Dining room,
hospital,-71
hotel,-82
hotel, floor pedestal lighting,-111
lighted from floor pedestals,-93
residence,-75
Dining rooms,-66, 67
Direct lighting,-115, 129
fixtures, spacing and hanging distances,-122
in church,-158
intensities recommended,-122
planning,-121
reflectors,-119
wattage recommended,-122
Directors' conference room, cove lighting,-91
Display case lighting,-181
Display rooms,-49
Display window lighting,-161
Dome of building, flood lighted,-193
Double deck show window,-172
Drafting rooms,-57
Drafting table,-190
Drawing rooms,-57
Drill hall,-152
armory,-139
Drilling department, factory,-131
Dust and dirt, effect of accumulation on indirect lighting equipment,-78
Dust cover for luminous bowl fixtures,-78
Duty rooms, hospital,-70

Effect of light on eye,-17
Efficiency of utilization,
direct lighting,-124
indirect lighting,-33
Electrolier pull switch,-79
Elevator lobby,-73
Entrance lobby, cove lighting,-91
Entrance of hospital,-69
Entrance of theatre,-64
Equipment for indirect lighting,-30
Erecting shop,-133
E-65 reflector,-91
Evangelistic Tabernacle,-150
Exchange floor, hotel,-52
Eye,
effect of intensity on efficiency of,-27
effect of light on,-17
efficiency, Ferree test for,-26
Eye-strain in schools,-53
Eyes, best light for,-21

Factory,-155, 156, 157
flood lighted,-215
indirect lighting in,-56, 83
lighting,-130
Fence, flood lighted,-217
Ferree test for eye efficiency,-26
Filing cases, lighted with Hoodette,-188
Fish net factory,-135
Fittings
for Scoopette,-185
for X-Ray reflectors,-120
Fixtures, artistic,-24
Flag lighting,-220
Flexibility of X-Ray indirect lighting system,-25
Flood lighting,-193
amusements,-219
applications of,-207
athletic grounds,-219
banks,-207
bridges,-216
buildings,-207, 222
bulletins,-212
calculations,-204
chimneys,-213
factories,-215
fences,-216
flags,-220
for auto displays,-221
for night construction work,-221
for protection,-215
for show window displays,-221
gardens,-219
how to install units,-218
industrial plants,-215
lamps for,-194
loading platform,-216
monuments,-211
mortuary,-209
office buildings,-207
pageants,-219
parks,-219
projectors,-195, 196, 198, 200
shipping platform,-216
signs,-212
store front,-223
stores,-207, 209, 223
streets,-216

Flood lighting,-193—*Continued.*
supports for projectors,-208
tanks,-212
theatres,-208
tower,-222
units for,-194
uses for,-194
wall bulletins,-212
Floor entrance method for Scoopette,-184
Floor pedestal,
for dining room lighting,-111
for solarium in club,-110
Floor pedestals, lighting from,-93
Foot candles,
direct lighting,-122
indirect lighting,-34
recommended for flood lighting,-205
Forge room, foundry,-132
Form "A" shade holder,-118
Form "H" shade holder,-118
Form "O" shade holder,-118
Foundries,-132
Foyer
of churches,-59
of theatre,-64
Frosting, light absorbed by,-237

Gallery, art museum,-154
Garage,-141
Gardens, flood lighted,-219
General illumination, direct lighting,-121
General office,-40
Glare, evils of,-115
Glass
absorption of,-237
ceilings in show windows,-173
for bank desk equipment,-226
for skylight,-147
Gospel barn,-150
Gothic fixture for churches,-61
Grill room,-66
Grocery department, public market,-144
Group lighting,-122
Gymnasium,-159
lighting,-140
lighting fixture,-140

High interiors,
armories,-152
factories,-133
Holders and lamps,
correct,-168
effect of wrong use,-168
Home,
lighting of the,-74
lighting with indirect portable lamp,-102
Hood, No. 731,-164, 165, 178
Hoodette,
for display cases,-186
for drafting table lighting,-190
manner of installing,-187
number to use,-187
spacing of,-187
special uses for,-188
Hoodettes for filing cases,-188
Hospital,
children's room,-71
diet kitchen,-70
dining room,-71
duty rooms,-70
fixtures,-71
office,-70
operating rooms,-72, 146
surgical room,-70
wards,-69
Hospitals,-69
Hotel,
dining room,-66, 67, 82
dining room, floor pedestal lighting,-111
music room, lighted from pedestals,-106
Hotels,-52

Illumination,
from concealed sources,-17
general,-121
local,-122
local-general,-122
intensity and wattage recommended for various requirements, direct lighting,-122
intensity and wattage recommended for various requirements, indirect lighting,-34
Illumination chart,
direct lighting,-126
indirect lighting,-37
Illumination computation diagram,-36, 127
Illumination data,
definitions,-etc.,-231
for projectors,-202
Imposing stone,-137
Indirect candelabra brackets,-99
Indirect illumination,
economical,-22
interiors suitable for,-29
Indirect lighting,-21
almost equal to daylight,-26
by column clusters,-96, 97
equipment for,-30
fixtures, spacing and hanging distances,-35
flexibility of system,-25
for display rooms,-49
from bank partitions,-92
from brackets,-98, 99
from column caps,-113
from coves and cornices,-90
from floor pedestals,-93
from wall boxes,-95
in banks,-44
in church auditoriums,-86
in clubs,-50
in drafting rooms,-57
in factory,-83
in hospital operating rooms,-72
in hotels,-52
in offices,-39
in schools,-53
in show room from column clusters,-108
in show windows,-175
in small store,-87
in stores,-45
in the industries,-56
intensities recommended,-34
method of calculation for,-33, 36
planning,-29
portable lamp,-101
reflectors for,-31
wattage recommended,-34
Individual control of lighting units,-138
Industrial accidents,-117
Industrial lighting,-129
Industrial lighting law,-116
Industrial plant, flood lighted,-215
Industries, indirect lighting in,-56
Installing, direct lighting reflectors,-120
flood lighting units,-216, 218
of "Hoodette,"-187
of "Scoopettes,"-184
show window reflector,-167

Intensity
of illumination recommended for direct lighting,-122
of illumination recommended for indirect lighting,-34
of light for show case displays,-183
Interiors suitable for indirect illumination,-29
Intrinsic brilliancy of various illuminants,-238
Island show window,-170

Jewelry store,-47
Jove, No. 600,-164, 165, 179
Jupiter, No. 610,-164, 165, 179

Kindergarten room,-54
Kitchen, residence,-76

Laboratories,-54
Lamp data,-35, 124
Lamps,
for bank desk equipment,-227
for flood lighting,-194
Lantern, direct lighting in church,-158
Laundry room, factory,-155
Law, industrial lighting,-116
Laws of light reflection,-19
Letter cases,-144
Libraries,-54
Library,
bookrack lighting,-188
bookstacks,-98
corridor,-98
in residence,-84
Light
absorbed by frosting,-237
control of,-19
laws of reflection of,-19
Lighting,-
direct,-22
effect, decrease due to dirt accumulation on equipment,-118
for outdoor plays,-148
from other than ceiling outlets,-89
from skylights,-145
indirect,-22
industrial,-129
laws, industrial,-116
methods,-22
of show windows,-161
of stage,-148
results from X-Ray Bank Desk equipment:-229
semi-indirect -22
Linotype machine room,-137
Living room,
lighted without ceiling fixtures,-102
residence,-74
Lobby,
hotel,-52
lighted by column clusters,-96
of hospital,-69
of public building,-73
of theatre,-64
Local-general illumination, direct lighting,-122
Local illumination, direct lighting,-122
Local lighting
for desks,-189
of drafting table,-190
over benches,-136
Lodge room, lighted from wall boxes,-95
Lodge rooms,-50
Loss of efficiency of eye,-26
Lounge,-50
of club,-81

Lowering device for large fixtures,-79
Lumen method
for direct lighting,-123
for indirect lighting,-33
Lumens of lamps,-35, 124
Luminous bowl
equipment for indirect lighting fixtures,-32
fixture, dust cover for,-78
fixture for office lighting,-41
fixtures for churches,-85
fixtures in stores,-87
principle,-22

Machine shop,-130, 156, 157
Machine tool department, factory,-133
Maintenance
of direct lighting systems,-118
of indirect lighting installations,-78
Mantel lighting unit,-99
Market, public,-144
Men's room in club,-50
Mill, flood lighted,-214
Mills,-135
Miscellaneous data,-237
Monument, flood lighted,-210
Mortuary, flood lighted,-209
Motion picture theatre, wall box lighting,-109
Moulding floor, foundry,-132
Multi-unit equipment for indirect lighting fixtures,-32
Museum of art,-145, 154
Music rack light,-190
Music room,
indirect pedestal lighting,-106
residence,-74

Night construction work,-221

Office
building, flood lighted,-207, 222
building, stair hall,-43
lighted by column clusters,-97
lighting,-39, 40, 41, 42
lighting with X-Ray luminous bowl fixtures,-80
with skylight,-147
Offices in hospitals,-70
Operating rooms, hospital,-72, 146
Outdoor plays, lighting for,-148
Outlet box covers,-120
Output, increased in industrial plants,-116

Pageants, flood lighted,-219
Painting gallery, art museum,-154
Parks, flood lighted,-219
Pedestal lighting in music room,-106
Pedestals, lighting from floor,-93, 94
Pennsylvania code,-116
Periodical reading room,-55
Piano lamp,-191
Picture lighting,-190
Pipe suspensions for direct lighting reflectors,-120
Planning
direct lighting,-121
indirect lighting,-29
show case lighting,-183
show window lighting,-169
Point-by-point method for direct lighting,-125
Poke Bonnet, No. 750,-166
Pool table,-142
Porch, residence,-77
Portable lamp for indirect lighting,-101
Postal station, letter cases,-144
Power plants,-136
Pressroom, printing,-137, 138
Printing plant,-137

Private office,-42
Projector,
illumination data,-202
lighting chart,-202, 203
No. 50, 51,-196
No. 60, 61, 62,-198
No. 91, 92,-200
Projectors for flood lighting,-195, 196, 198, 200
Proof reading room,-138
Protective flood lighting,-215
Public library,-55
Public market,-144
Public space in bank, cove lighting,-112
Public spaces,-73
Pull switch for fixtures,-79
Pumping station,-136

Quantities, definitions of,-231
Quick calculations,
direct lighting,-126
indirect lighting,-37

Railroad bridge, flood lighted,-217
Reading room,-54, 55
Receptacles,-120
Reception hall, lighted from floor pedestals,-94
Reflecting power of painted surfaces,-237
Reflection
coefficient,-237
of light,-19
Reflective qualities of reflectors,-117
Reflector
diffuser,-23
for bank desk equipment,-226
No. E-65,-91
X-Ray,-13
Reflectors
for direct lighting,-119
No. 54 (Jumbo),-119
No. 515,-91
No. 535, 570, 575, 580, 696, 700, 710,-119
for efficient indirect lighting,-31
for flood lighting,-196, 199, 201
No. 800, 810,-196
No. 825, 827,-201
No. 835, 840, 845,-199
for indirect lighting,
No. EC-12, EC-14, E-15, EC-15, E-40, E-60, EC-71, E-155, EC-344, EC-345, EC-346, EC-751, EC-754, EC-758,-31
for Mazda "C" lamps,-30
for show window lighting,-164, 165, 178, 179
No. 600, 610, 731, 778,-165
No 750,-166
Regular reflection,-19
Residence
library,-84
lighting,-74
lighting with indirect portable lamp,-102
Residences,-74
Restaurants,-66
Rest rooms,-51
Rug display rack,-151

Sales room, auto,-108
School, cafeteria,-67
Schools,-53
Scoop No. 778,-164, 165, 178
Scoopette,
advantage of,-182
case lighting with,-183
compared to other appliances,-182
fittings for,-185
for adding machine,-191
for music rack,-190
for piano lamp,-191
for picture lighting,-190
for show case,-181
installing of,-184
number to use,-183
planning show case lighting with,-183
outfits for show cases,-183
spacing of,-183
special uses for,-188
Selection of show window reflectors,-166
Service station, auto,-141
Sewing machine department,-135
Sewing room, indirect lighting in,-56
Shade holders,-118, 120, 167
Shipping platforms, flood lighted,-216
Shop,
erecting,-133
machine,-156, 157
Shops, candy, etc.,-49
Short cut method of calculation
for direct lighting,-127
for indirect lighting,-36
Show case displays, intensity of light for,-183
Show case lighting,-181
Show room,
auto,-108
lighted from floor pedestal,-93
Show window,
arcade type,-170
island type,-170
lighting,-161
lighting, planning,-169
selection of equipment,-169
typical,-169
valance,-177
Show window reflectors,-164, 165
installed above ceiling,-170
installing of,-167, 170
selection of,-166
spacing of,-167
Show windows,-178, 179
classified,-163
cove lighting in,-175
diffused lighting for,-176
double deck,-172
indirect lighting for,-175
with glass ceilings,-173
Signs, flood lighted,-212
Skylight glass,-147
Skylight lighting,-145
Small stores,-47
Social rooms of church,-60
Sockets,-120
Solarium of club, lighted from floor pedestal,-110
Soldiers and Sailors monument, flood lighted,-210
Spacing distances,
direct lighting fixtures,-122
indirect lighting fixtures,-35
Spacing show window reflectors,-167
Special containers for indirect reflectors,-99
Spread reflection,-19
Spoilage in industrial plants,-117
Spooling department, mill,-135
Squash racket court,-143
Stage lighting,-148, 153
Stairhall, office building,-43
Station waiting room,-73
Stock quotations board,-151
Store, lighted by column clusters,-96
Stores, flood lighted,-192, 207, 223
Stores,-45, 46, 47, 48, 87
Street, flood lighted,-217
Study rooms,-53

Sub-station, power plant,-136
Sun room,-77
  in club, floor pedestal lighting,-110
"Sunday" Tabernacle,-150
Supporting bank desk equipment,-229
Supports for flood lighting projectors,-208
Surgical dressing room,-70
Suspension chart,
  direct lighting fixtures,-122
  indirect lighting fixtures,-35
Swimming pool,-143, 147
Symbols for wiring plans,-236

Tabernacle, Evangelistic,-150
Tanks, flood lighted,-212
Tea room,-49
  lighted with indirect portable lamp,-104
Teller's cage,-225
  local lighting with Brackette,-189
Tennis court,-150
Tennis, squash court,-143
Terms, definitions of,-231
Textile mills,-135
Theatre,
  auditorium lighted from wall boxes,-109
  club room,-50
  cove lighting,-107
  entrance, cove lighting,-91
  flood lighted,-208
  lobby, lighted from floor pedestals,-94
  stage lighting,-148, 153
Theatres,-64
Tower, Woolworth, flood lighted,-206
Transformer room, power plant,-136
Type frame, lighting for,-137
Typesetting,-137

Underwear factory,-135
Units,
  definitions for,-231
  for flood lighting,-194
Uses for flood lighting,-194
Utilization efficiency,
  of direct lighting,-124
  of indirect lighting,-33

Valance for show windows,-177
Vestibule of churches,-59

Waiting room,-73
Wall boxes,
  for indirect lighting in theatres,-109
  for indirect lighting reflectors,-95
Wall bulletins, flood lighted,-212
Wall display case lighting,-186
Wards, hospital,-69
Wash rack, in garage,-141
Washington Monument, flood lighted,-211
Watt per square foot method,
  direct lighting,-121
  indirect lighting,-36
Wattage consumed by X-Ray Bank Desk equipment,-227
Wattage recommended
  for direct lighting,-122
  for indirect lighting,-34
Watts per square foot,
  direct lighting,-122
  for flood lighting,-204
  indirect lighting,-34
Weave room,-134
Winch, worm gear for lowering large fixtures,-79
Wiring symbols,-236
Woolen mill,-134, 135
Woolworth Tower, flood lighted,206, 222
Workroom, indirect lighting in,-56
Workroom lighting,-130

X-Ray Bank Desk lighting,-225
X-Ray direct lighting,-115
  applications of,-129
  planning,-121
  reflectors, uses for,-121
X-Ray flood lighting,-193
X-Ray indirect lighting,
  applications of,-39
  flexibility of indirect lighting system,-25
  general principles,-21
  methods of calculation for,-33
X-Ray projectors,-195, 196, 198, 200
X-Ray reflectors,-13
  advantage of, for industrial lighting,-116
  classified,-118
  fittings for,-120
  for Maxda "C" lamps,-30
X-Ray show case lighting,-181
X-Ray show window lighting,-161

12
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